Focus on strength

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Design, Development, Production, Implementation and Evaluation of an Overweight Prevention Program.

Gill A. ten Hoor

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DISSERTATION

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Gill A. ten Hoor

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Prologue

"The obesity prevalence is still rising"
"Obesity is a growing health problem globally"
"More and more children are obese, and children who are obese become obese adults".

Many of the chapters you will read in this dissertation will start with a statement that we (and our children) are becoming heavier, that overweight and obesity are established risk factors for chronic metabolic and cardiovascular diseases, and that 'something' has to be done to make people healthier. This is our attempt.

On the 12th of August 2011, it all started with Guy Plasqui (Human Biologist), Gerjo Kok (Applied Psychologist) and Gill ten Hoor (something in between). In a brainstorm meeting, a white sheet of paper was soon filled with ideas of how we could contribute to a solution. We immediately agreed that obesity is a multidisciplinary problem, where a multidisciplinary approach was needed. Not long after that meeting, a team of biologists, health promotors, movement scientists, psychologists, and a youth health care expert was gathered. ***"Focus on Strength'*** was born.

As ***Focus on Strength*** team we did not attempt to solve obesity per se, but obesity-related health issues. From a biological perspective, we therefore wanted to stop focusing on losing body weight, and decided to concentrate on improvements in body composition (that is: the ratio of fat-free mass and fat mass). From a psychological perspective we did not want to focus on what people *have* to do to become healthier, but on what they *want* to do. Our answer was: ***strength exercises*** (or resistance exercises; we will use these terms interchangeably). Although for now this answer - "strength exercises" – might seem to be too simple for solving the complex obesity problem, strength exercises might contribute to a solution on many levels. From a biological point of view, it is a fact that people who are overweight or obese are often stronger (in absolute sense) and better in (absolute) strength exercises compared with normal weight people. Under the right circumstances, people who are overweight might notice that strength exercises are easier than aerobic exercises and that their performance is better than the performance of their normal weight counterparts. Using psychological principles from the *Social Comparison theory* and *Self Determination Theory*, improving overweight peoples' feelings of competence could make them more motivated to engage in strength exercise and ultimately make them maintain a more active lifestyle. Additionally - and not unimportant - strength exercises promote a healthier body composition, having positive effects in combating the negative health consequences of obesity. In **PART I. THE INTRODUCTION TO AN IDEA** of this dissertation, we introduce the rationale behind the ***Focus on Strength*** program in more detail: in **Chapter 1** with a more biological perspective, in **Chapter 2** with a more psychological perspective.

Although we were convinced of our ideas – that strength exercises seemed to be a fruitful way to go - not all assumptions were scientifically tested, and niches in our knowledge needed to be

filled. These are addressed in **PART II. THE RIGHT TRACK CHECK**. Although a lot of empirical evidence existed for the biological benefits of resistance training we had limited knowledge about the psychological benefits. As a first step towards considering strength exercises in health behavior change interventions targeting overweight and obesity, it was necessary to systematically map what is known about the psychological consequences of strength exercise. In a systematic literature research, we examined the current knowledge of 'the psychological strengths of strength exercises' in people with overweight or obesity in **Chapter 3.** In **Chapter 4,** we bridged the gap between biological and psychological insights in the management of obesity, by examining the putative physiological and psychological benefits of strength exercises for people who are overweight or obese in a cross-sectional study using gold standard measurements.
Lastly, in **Chapter 5,** we examined parental attitudes about physical activity behavior in general and aerobic and strength exercises in particular. One of the hypothesized factors that contribute to low participation of youngsters in strength exercises or strength-oriented sports is the parent's attitude regarding this type of exercise for youngsters. Parents have a crucial role in children's physical activity-related behavior. They are largely responsible for the type and amount of physical activity of their child, and are role models influencing their child's physical activity behavior. Although strength exercises have both physiological and psychological health benefits across all ages, they are erroneously considered to adversely affect health status in youngsters. To develop and implement tailored physical activity interventions for youngsters it was important to identify parents' attitudes about their children's participation in such exercises.

After we found out that we were on the right track in Part II, we continued to develop an intervention program based on strength exercises **(PART III. THE DEVELOPMENT OF AN INTERVENTION)**. In our ***Focus on Strength*** program, it was important to be able to measure both body composition and strength in large groups of 11-13 year old adolescents. The most frequently used dynamometer is the handgrip dynamometer because of its cost effectiveness, simplicity and portability. However, movement patterns performed during the execution of the handgrip test are not comparable to movement patterns of larger muscle groups, or performed in daily life or exercise training programs. To overcome this limitation, we evaluated the back-leg-chest dynamometer - as an effective, simple and portable way to test total body strength. This can be read in **Chapter 6.**

In **Chapter 7** The Dutch ***Focus on Strength*** intervention study protocol is described, including the program design and production, implementation and evaluation plan. To optimally use the benefits of social comparison and to minimize obesity stigma we focused on the general 11-13 year old high school population, and not only on youngsters who are overweight or obese. The development of the ***Focus on Strength*** intervention was based on the *Intervention Mapping* (IM) protocol. With this, we described the iterative path from problem identification to problem solving or mitigation. The six steps of IM comprise several tasks each of which integrates theory and evidence. The completion of the tasks within a step created a product that guides the subsequent step. The completion of all of the steps served as a blueprint for designing, implementing and evaluating our intervention based on theoretical, empirical and practical information.

PART IV. AN EFFECTIVE PROGRAM? reports on the effect of the ***Focus on Strength*** program on body composition as a proxy for health. In our intervention program **(Chapter 8)**, 695 adolescents (aged 12-15 years) participated in the randomized controlled trial. The program started in March 2015 and ended one year later in March 2016. In this intervention program, we examined the influence of strength exercises and a motivational program on body composition and physical activity behavior. Influences on secondary outcomes will follow later and will be published at http://focusonstrength.net.

In our last and final part, **PART V. NOW WHAT?** the ***Focus on Strength*** idea, program, and outcomes are discussed in **Chapter 9.** In this chapter, we also discuss practical implications and future research directions. Part V ends with a **valorisation paragraph,** in which the knowledge gathered during our research is translated to societal value.

PART I
THE INTRODUCTION TO AN IDEA

Chapter 1

Combating adolescent obesity: an integrated physiological and psychological perspective.

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Abstract

Purpose of review: Optimizing the approach to combat childhood obesity, we emphasize the importance of combining both biological and psychological knowledge. In such an approach, strength exercises might be an important aspect in the treatment and prevention of childhood obesity.

Recent findings: Recent evidence indicates plausible effects of the role of resistance exercise in combating the negative health effects of childhood obesity. When looking at body composition, youngsters who are overweight do not only have a higher fat mass, but also a higher muscle mass compared with their normal-weight counterparts. With that, they are also stronger and better in exercises wherein the focus is on absolute strength, making them – under the right circumstances – more motivated to engage in resistance exercise and ultimately maintain a physically active lifestyle.

Summary: More and more children are obese, and children who are obese become obese adults. One reason that youngsters who are obese are not physically active is that they are outperformed by normal-weight youngsters, and one reason they are overweight is because they are not physically active. To combat childhood obesity, strength exercise might be a solution to break the vicious cycle.

Introduction

Nowadays, the news that the overweight and obesity prevalence is still rising (Mirza & Yanovski, 2014; Seidell, 2014) is not a revelation anymore. More and more children are obese, and children who are obese become obese adults (Hunger & Yomiysms, 2014; Kelsey et al., 2014). The obesity 'epidemic' – and related noncommunicable diseases (NCDs) – are begging for action (World Health Organization, 2011).

In the 2013 Vienna Declaration on Nutrition and Noncommunicable Diseases in the Context of Health 2020, a healthy diet and physical activity are recognized as factors that should be improved to reduce obesity and NCDs, especially in children. In the European Action Plan on Childhood Obesity 2014–2020, the goal was stated to stop the rise in overweight and obesity in youngsters (0–18 years) by the year 2020 with, besides targeting nutrition, a greater focus on physical activity promotion. In this article, we focus on the physical activity aspect, and emphasize the importance of combining both biological and psychological knowledge.

Physical activity recommendations and obesity

For 5–17 year olds (in general), the World Health Organization recommends at least 60 min of moderate-to-vigorous-intensity physical activity per day, mostly aerobic (World Health Organization, 2011). Lee et al. (2012) argue that health is affected substantially when those recommendations are not met. We believe that these guidelines are not effective enough for overweight and obese 5–17 year olds. We argue that when it comes to physical activity, we have to bear in mind that youngsters who are overweight or obese are not 'general normal–weight' youngsters and hence different guidelines will apply. First, although it is a commonly accepted fact that in the treatment of obesity the physical activity guidelines should be met, less than 20% of US adolescents meet those guidelines with even lower rates among obese 12–17 year olds (Song et al., 2013). Other studies also report that obese youngsters often have more difficulties in meeting the physical activity guidelines compared with normal-weight people (Lowry et al., 2013; Wafa et al., 2014).

Second, although the WHO recommendations state that the emphasis should be on aerobic exercises, people who are overweight or obese are not only physically limited by their weight when it comes to the performance of aerobic exercises (Pataky et al., 2014), but they also have higher risks of injuries with aerobic exercises (McHugh, 2010). Third, to stimulate overweight people to be more physically active, and for long-term compliance, it is important not to focus on what overweight youngsters have to do, but on what they like to do (Ekkekakis & Lind, 2006; Kok et al., 2014). Humans have the tendency to compare their own abilities with others' abilities to value themselves: social comparison (Forsyth, 2014). With that, people gain in self-worth when they appear to be better on a certain dimension (e.g., 'I am faster') and lose in self-worth when they are outperformed (e.g., for overweight and obese youngsters when it comes to aerobic exercises). As a consequence, they might focus on a different dimension to compare themselves favorably with similar others (e.g., 'I am better in computer games' or 'I am better in Geography') (Van Knippenberg et al., 1981). At the end of the day, a vicious cycle appears. One reason that overweight people are not physically active is that they are outperformed by normal-weight people, and one reason they are overweight is because they are not physically active.

Breaking the cycle

To break this vicious cycle, we first have to shift our focus away from body weight adjusted for height (BMI) as an individual metabolic and mental health measure. BMI is a good tool for risk estimates in large populations, but not the right tool for individual evaluations (Bogin & Varela Silva, 2012). One's BMI is a bad predictor of one's body composition, and focusing on BMI might have stigmatizing effects on one's health in later life (Hunger & Tomiyama, 2014).

Finally, instead of focusing on the present physical activity guidelines, with poor compliance (Kann, 2013; Song et al., 2013; Wafa et al., 2014), it might be more appropriate to focus on health behaviors people like to do. From a metabolic perspective, physical activity can be distinguished in an aerobic sub dimension and a resistance sub dimension. Although normal-weight youngsters perform better on aerobic exercises, overweight and obese youngsters will perform better on strength exercises, and as a consequence gain self-worth ('I am stronger') (**see also Chapter 4**). To break the cycle, these resistance exercises might be the solution.

Physiological and psychological benefits of resistance training

When looking at body composition, overweight youngsters do not only have a higher fat mass, but also a higher muscle mass compared with their normal-weight counterparts (**see also Chapter 4).** With that, they are also stronger and better in exercises where the focus is on absolute strength (Colella et al., 2009; **see also Chapter 4**), making them under the right circumstances more motivated to engage in resistance exercises (Patall et al., 2014) and ultimately maintain a physically active lifestyle.

There is increasing evidence to shift focus from rapid short-term weight loss to gaining long-term health. Quickly losing weight may have short-term successes, but one often ends up in a fast weight regain because of several mechanisms (the so-called 'yoyo effect', for detailed information about known mechanisms, see Mariman, 2012; Ochner et al., 2013). By quickly losing weight by caloric restriction, amongst others, one's energy expenditure also adjusts to a lower energy intake making long-term dieting a necessity for the maintenance of lost weight (Tremblay et al., 2013). At the same time, a proportionally high decrease of leptin levels (the 'satiety hormone'), increased ghrelin levels (induces hunger), decreased peptide YY3–36, and cholecystokinin (induce satiety), and increased neural responsivity make people who quickly lose weight often surrender to a higher energy intake (Ochner et al., 2013). Furthermore, another hypothesized cause of a fast weight regain is that by quickly losing weight, the size but not the number of fat cells reduces. The adipocytes get 'stressed', and try to compensate by an increased uptake of glucose and fatty acids (Mariman, 2012). Obviously, to achieve long-term health effects, quickly losing weight is not the answer.

Lately, the short-term and long-term benefits of youth resistance exercises become more and more evident (for an elaborate overview, see Lloyd et al., 2014). Although resistance exercises do not meet one's desire of a decreased weight or BMI per se (Kelley & Kelley, 2013), they can increase one's fat-free mass (Cloutier et al., 2014; Schranz et al., 2013), body composition, strength, and energy balance on the long term (Lloyd et al., 2014; Paoli et al., 2015;Vasquez et al., 2014). Instead of losing weight, providing feedback about body composition can be a solid and sufficient motivator for continuing resistance exercise (Pescud et al., 2010).

The benefits of an improved body composition are not only a higher energy balance (also a higher post exercise oxygen consumption (Paoli et al., 2015) and decreased leptin levels (Mohebbi et al., 2013)), but also improved insulin sensitivity, lower chances on cardiovascular disease, blood pressure, and cholesterol levels (Paoli et al., 2015; Tibana et al., 2013; Vasquez et al., 2014). After a 3-month strength training exercise program, Vasquez et al. (2014) for example found improvements of obese children's cholesterol levels (increase in high-density lipoprotein cholesterol, and decrease in total cholesterol). One's increased strength can also improve one's motor skills (Lloyd et al., 2014).

From a psychological point of view, there is only limited information about the mental health effects of strength training in overweight or obese people (Lloyd et al., 2014; Schranz et al., 2013). In a recent literature review, positive effects of resistance training in overweight people on quality of life-related outcomes and beliefs were found (**see also Chapter 3**).

Other considerations and misconceptions

Although resistance exercises may have both biological and psychological benefits in the obesity 'challenge' (Schranz et al., 2013; 2014), other factors need to be considered in implementing this approach. Without parental support, (overweight) youngsters will not engage in resistance exercises (Davison et al., 2013). In a recent study about parental opinions about their child's physical activity behavior, we found that about one-third of the parents of 12–15 year olds would not allow their child to perform resistance exercises (**see also Chapter 5**). The most mentioned reasons against resistance exercises were that their child was too young, and that at their age, strength exercises were considered unhealthy. The idea that strength exercises are unhealthy is a persistent misperception. As long as they are performed under qualified supervision, it can even prevent injuries and cause a rapid rehabilitation from injuries (Lloyd et al., 2014).

Another important point is that youngsters should not become little body builders, nor should aerobic components be completely banned. An important consideration for social comparison – which might trigger overweight people to become more physically active when there is a strength aspect involved – is not only that overweight youngsters are better than normal weight youngsters, but also that overweight and normal-weight youngsters exercise together, and that there is a mutual appreciation between the youngsters in each other's performance. It is evident that when normal-weight and overweight youngsters are not physically active together, there is no social comparison, as overweight youngsters will not find out that they in fact perform better than normal-weight youngsters. Also, when there is no mutual appreciation (e.g., normal-weight youngsters attribute the better strength performance of overweight youngster to 'because they are heavy' and not to 'because they are strong'), the positive effects of the social comparison are devaluated. A possible manner to accomplish this is to develop a physical activity team-task with both aerobic and (absolute) strength components, wherein the team (and not the individual) will be evaluated per task at the level of the best team member (which is most satisfying for all group members; Forsyth, 2014). Because youngsters work in teams, the focus is on performance and not on weight. With that, the level of stigmatization is limited to a minimum (Hunger & Tomiyama, 2014).

Conclusion

Obesity is a multidisciplinary problem, and a multidisciplinary approach is needed. Therefore, it is not only important that scientists with expertise in different areas work together, but also governments and industries collaborate. We do not have to solve obesity per se, but obesity-related health issues. On many levels, strength exercises might contribute to this solution. The approach proposed here has the abilities to make overweight youngsters more (motivated to be) physically active, and more healthy by means of a healthier body composition; not by focusing on the current aerobic-focused physical activity guidelines, one's BMI, or the idea that overweight youngsters have to lose weight, but by focusing on their strength and on what overweight youngsters like to do.

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Chapter 2

A new direction in psychology and health: Resistance exercise training for obese children and adolescents.

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Introduction

Obesity is a growing health problem globally (Swinburn et al., 2011). It is an established risk factor for chronic metabolic and cardiovascular diseases (Kelsey et al., 2014; Washington, 2008). In overweight and obese children and adolescents (5–17-year olds; further referred to as youngsters), not only metabolic health, but also psychological well-being is at risk (Cooke et al., 2000; Kelsey et al., 2014; Van der Baan-Slootweg et al., 2010).

Besides overeating and genetic susceptibility, an insufficient level of physical activity is one of the main contributors to childhood overweight and obesity (Kremers et al., 2005), and the target of many obesity reduction programs (Lee et al., 2012). Recent meta-analyses, however, show no effects of present physical activity programs on body weight or body mass index (BMI, Guerra et al., 2013; 2014; Harris et al., 2009), blood pressure (Guerra et al., 2013) or physical activity level (Metcalf et al., 2013). In this editorial, we highlight the putative physiological and psychological benefits of resistance exercise training for obese youngsters as a relatively new direction in psychology and health.

The focus of a new program

In our view, a long-term effective physical activity program for overweight youngsters can be accomplished by combining biological and psychological knowledge. We think that current exercise programs for overweight and obese youngsters are based on incorrect assumptions, as they tend to focus predominantly on aerobic exercises and weight loss (Faigenbaum, 2007). We hypothesise that a physical activity program should initially aim for obtaining a healthier body composition rather than weight loss, i.e., a relatively higher fat-free mass and a relatively lower fat mass. Improving the fat-free mass/fat mass ratio may increase energy metabolism and decrease the risk of chronic diseases (Dixon, 2010).

Overweight youngsters can often not compete with normal weight youngsters when it comes to aerobic exercises (Faigenbaum et al., 2009). Instead, resistance exercises might be easier for overweight youngsters and therefore easier to comply with (Colella et al., 2009; Riddiford-Harland et al., 2006). Additionally, when they participate in those resistance exercises, it might have a positive effect on their muscle (fat-free) mass (Lau et al., 2004; Schranz et al., 2013; Yu et al., 2008). We argue that the focus of physical activity should be less on what these youngsters have to do, and more on what they like to do. This mindset might lead to long-term compliance in physical activity behavior (Fishbein & Ajzen, 2010; Vansteenkiste et al., 2007). In order to become healthier in the long term, we suggest obesity reduction programs in overweight youngsters that focus more on resistance exercises.

Resistance training as innovation in practice

Resistance exercises, whereby an individual is working against a wide range of resistive loads to enhance health (Lloyd et al., 2014), are not a new idea. In the past, it has been suggested that resistance exercises are harmful for youngsters, particularly during growth (i.e., growth plate injuries or stunted growth). However, more recent data indicate that this is a persistent misperception devoid of any evidence (Barbieri & Zaccagni, 2013; Benjamin & Glow, 2003; Benson et al., 2008; Faigenbaum, 2007; Faigenbaum & Myer, 2010; Lloyd et al., 2014). As long as resistance exercises are performed under qualified supervision, they can even prevent injuries and cause a rapid rehabilitation from injuries (Lloyd et al., 2014; Sothern et al., 2000). In fact, since

2008, public health agencies included resistance training as part of their physical activity guidelines for youngsters (Department of Health, Physical Activity, Health Improvement & Protection, 2011; McCambridge & Stricker, 2008; United States Department of Health & Human Services, 2008; World Health Organization, 2010).

Earlier studies have already suggested the use of resistance exercises in (overweight) youth (see, e.g., Faigenbaum, 2007; McGuigan et al., 2009; Sothern et al., 2000). However, the link between the focus on the biological strengths and the positive psychological consequences that it may yield is still undervalued. From a biological perspective, there is a consensus that most youngsters and adults with overweight do not only have an absolute higher fat mass but also an absolute higher fat-free mass than their lean counterparts (Westerterp et al., 1995). Consequently, they have more muscle mass, making them stronger in an absolute sense, and less limited in the performance of resistance exercises. Empirical evidence shows that overweight youngsters perform even better on resistance-based exercises than their normal weight peers (Colella et al., 2009; Riddiford-Harland et al., 2006). Furthermore, by performing resistance exercises one's fat-free mass increases, resulting in long-term positive effects on metabolic and cardiovascular health (Alberga et al., 2013; Lloyd et al., 2014).

From a psychological point of view, interventions focusing on behavior change are most effective when perceived behavioral control for performing the new behavior is high, and the new behavior has positive outcome expectations (e.g., more fun) and is more intrinsically rewarding (Ekkekakis et al., 2006; Fishbein & Ajzen, 2010; Fortier et al., 2009; Rhodes et al., 2009; Ryan & Deci, 2002). Compared to normal weight youngsters, overweight youngsters are less capable of performing at a desired or comparable level in aerobic exercises (D'Hond et al., 2008; Faigenbaum et al., 2009). These negative experiences may result in disinterest and a loss of motivation, causing a vicious cycle: the loss of motivation causes individuals to disengage from physical activity. This lack of physical activity causes an increase in weight, which in turn may result in even lower levels of physical activity. We expect that overweight youngsters will notice that resistance exercises are easier than aerobic exercises and that their performance will be better than the performance of their normal weight counterparts. As a consequence, their enhanced feelings of competence may induce an increase of autonomous motivation for physical activity, which is required for sustained behavior change (Silva et al., 2011). We therefore expect that in the long term, these overweight youngsters will feel fitter, stronger, more confident, and they will perceive physical activity as more positive. The hypothesised psychological gains (e.g., enhanced feelings of competence and perceived behavioral control) are lacking in programs focusing on aerobic exercises (Ryan & Deci, 2002).

Current evidence for psychological strengths

Empirical evidence exists for the biological benefits of resistance training (see, e.g., Lloyd et al., 2014), but we have limited knowledge about the psychological benefits of resistance training. In a review by Schranz et al. (2013) on the effects of resistance training for overweight youngsters, empirical support for large positive effects on muscle strength and small positive effects on body composition were reported. However, the effects of resistance training on psychosocial outcomes remained unclear because of the limited number of studies available. In a later Randomized Controlled Trial (RCT), Schranz and colleagues (2014) found large increases in strength, perceived behavioral control, confidence and self-esteem during and immediately after a six months resistance training program compared to a no intervention control group. However, six months after the intervention had ceased, the adolescents' outcomes had returned to baseline levels. Velez, et al.

(2010) reported improved competences and self-worth in both normal and overweight adolescents after 12-weeks of resistance training, compared to regular physical activity education training. Lubans et al (2010) found a significant improvement in perceived body attractiveness in secondary school girls after resistance training and compared to a control group maintaining their normal physical activity and nutrition behavior. Yu et al. (2008) found that in a strength exercise group of obese children (but not in a diet-only group), the physical self-concept in endurance improved. Lau et al. (2004) found non-significant improvement in obese adolescents' anxiety levels with no additional effect of strength training. In a qualitative study, Pescud and colleagues (2010) reported pleasant social interactions, improved confidence and self-esteem, and ongoing parental support as factors for continuation in a resistance program for the children.

Research Agenda

To develop a long-term effective resistance-based physical activity program, there are still several issues that need to be answered. First, the right methods should be identified to convince parents of the benefits of resistance exercises. Youngsters often do not engage in resistance exercises, because parents lack knowledge about resistance training. This was shown in a recent cross-sectional study among 314 parents of 12- to 15-year olds, where 93 parents (29.6%) stated that they would not allow their child to perform resistance exercises (**see also Chapter 5**). Almost half of them (n = 42) indicated the child being too young, or considered resistance exercises not healthy during growth. Interestingly, Pescud et al. (2010) describe that parents can learn to accept positive changes in body composition as desirable outcomes of strength training instead of weight loss.

Second, to make programs sustainable, youngsters need to be guided from supervised settings to non-controlled settings where they remain physically active. Adding motivational techniques such as motivational interviewing (Naar-King & Suarez, 2011; Ryan & Deci, 2002) might be helpful to strengthen the motivation for change and enhance behavioral maintenance by focusing on what youngsters like to do. Motivational interviewing is

> a collaborative, goal-oriented style of communication with particular attention to the language of change. It is designed to strengthen personal motivation for and commitment to a specific goal by eliciting and exploring the person's own reasons for change within an atmosphere of acceptance and compassion (Miller & Rollnick, 2013).

Randomised controlled trials should evaluate the immediate and long-term effectiveness of a combined resistance and motivational intervention.

Third, further research is required on how possible program characteristics (e.g., intensities, quantities, form of exercise, feedback mechanisms) can be tailored to the individual (e.g., for the same exercise, an overweight adolescent lifts a heavier weight than a lean adolescent) or group level (e.g., girls may prefer other resistance exercises than boys, Biddle et al., 2014). For example, it will be a challenge to develop resistance exercises that are attractive to adolescent girls. Therefore, the development of an adequate program of resistance exercises requires active participation of all stakeholders (including the target population, sports clubs, and physical education teachers).

A fourth research topic is the under-investigated relation between social comparison and self-determination. Given that overweight youngsters are better in resistance exercises than normal weight youngsters, applying social comparison theory (Lemaine, 1974; Suls et al., 2002; van Knippenberg et al., 1981) would suggest having overweight and normal weight youngsters exercising together. Overweight youngsters may find out that they perform better in the domain of resistance exercises (contrary to the domain of aerobic exercises), which, in time, is hypothesised to improve their self-worth. Some authors (e.g., Ames & Archer, 1988) have suggested that stimulating social comparison may have detrimental effects on autonomous motivation. However, O'Keefe, et al. (2013) suggest that social comparison is part of typical classroom settings and therefore unavoidable. Note that we do not suggest promoting 'outperforming others', as this might relate to more controlled types of motivation, but a positive comparison with others for youngsters who are used to only experiencing negative comparisons. Moreover, Senko et al. (2011) argued that normative-based performance goals often facilitate classroom achievement. Standage and colleagues (2003) found that perceptions of competence and relatedness are more predictive of self-determined motivation than autonomy, but also that normative feedback that is repeatedly negative will lead to a-motivation. We think that, next to promoting autonomy (e.g., by giving youngsters choices; Deci & Ryan, 2000), positive social experiences of overweight youngsters with resistance exercises may increase their perceptions of competence, their self-worth, and in time, their intrinsic motivation for exercise. Moreover, having youngsters compete as teams in multi-component exercises, might encourage interpersonal appreciation of various skills, e.g., speed Vs strength. This is a topic for further research. The relation between social comparison theory and self-determination theory has rarely been studied empirically (Neighbors & Knee, 2003).

Conclusion

We have argued that new physical activity directions for overweight and obese youngsters might benefit by a stronger emphasis on resistance exercises, whereas a motivational intervention might stimulate them to engage in these exercises. When it comes to overweight and obese youngsters, based on the currently available evidence, we suggest to stop emphasising their overweight, stop pushing them for weight loss, and to start focusing more on resistance exercises. In our view, it is time to start concentrating on their biological strengths and using psychological principles and techniques to make youngsters aware of these strengths. Only then long-term behavior changes and long-term health benefits may be achieved. To make overweight and obese youngsters healthier, stronger, more confident (and feeling better in general), resistance exercise may be the fruitful way to go.

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PART II
THE RIGHT TRACK CHECK

Chapter 3

The psychological effects of strength exercises in people who are overweight or obese: a systematic review.

Ten Hoor GA, Kok G, Peters GJY, Frissen T, Schols AMWJ, Plasqui G, The Psychological Effects of Strength Exercises in People who are Overweight or Obese: A Systematic Review (Sports Medicine: accepted for publication).

Abstract

Background: Overweight and obesity are a problem with high burden to well-being and society. Strength training has positive effects on body composition and metabolic health for people who are overweight or obese. The evidence for psychological effects of strength exercises is unclear. The aim of this study was to assess the psychological effects of strength exercises for people who are overweight or obese.

Methods: Relevant literature was identified by use of the PubMed and PsycINFO databases. For each study, effect sizes and corresponding variance estimates were extracted or calculated for the main effects of strength exercises on psychological outcomes.

Results: Seventeen studies were included. There was almost no overlap among the various measures of psychological constructs. The constructs were ordered into eight broad categories. Meta-analytical techniques revealed substantial heterogeneity in effect sizes, and combined with the low number of effect size estimates for each outcome measure, this precluded meta-analysis. Organization of the data showed that the evidence base so far does not show convincing effects of strength training on psychological outcome measures. Some weak effects emerged on self-efficacy, self-esteem, inhibition, and psychological disorders (e.g., anxiety and depression). No additional or comparable effects to other interventions were found for mood, outcome expectations, quality of life, and stress.

Discussion: The main finding of this review is that despite a strong theoretical basis for expecting positive effects of strength training on psychological outcomes, the literature shows a large gap in this area. The existing research does not show a clear picture: some positive results might exist, but there is a strong need to accumulate more evidence before drawing conclusions.

Key Points

- The literature on the effects of strength exercises on psychological outcomes is fragmented in terms of outcome measures and shows considerable heterogeneity.
- Synthesis of the outcomes shows weak effects of strength exercises on psychological outcomes.
- This incompleteness of the evidence base, in combination with the strong theoretical basis for assuming positive effects of strength exercises on psychological outcomes, implies an urgent need for more research.

Introduction

Overweight and obesity are worldwide problems with high costs to society and well-being (NCD Risk Factor Collaboration, 2016; Swinburn et al., 2011). Being physically active can both prevent and decrease overweight and obesity (Heath et al., 2012). The substantial public health benefits of successfully promoting exercise in these populations has resulted in a multitude of behavior change interventions targeting exercise. However, meta-analyses showed that few such attempts yielded the desired results (Guerra et al., 2013; 2014; Harris et al., 2009; Metcalf et al., 2013). It was recently argued that these failures may be partly explained by the wrong choice of behavioral change (see **Chapter 1 and 2)**, i.e. many exercise interventions often promote aerobic exercises (see next paragraph). People who are overweight or obese differ from non-overweight people in that they have more weight to carry during exercises. In an absolute sense, this means that, in addition to a higher fat mass, they have higher muscle mass compared to the non-overweight people (Westerterp et al., 1995).

These biological differences have not yet been translated to the health psychology field. They could be of substantial benefit to intervention development efforts as health psychology theories make interesting predictions about these dynamics. For example, whereas people who are overweight or obese are unlikely to have mastery experiences when engaging in aerobic exercise, this is much more likely when they engage in strength exercise. Therefore, strength exercise will likely result in increased self-efficacy (e.g., Bandura, 1986; Kelder et al., 2015). Self-efficacy is an important determinant of health behavior (Fishbein & Ajzen, 2010), including exercise behavior (Hagger et al., 2001). Similarly, when exercising together with non-overweight peers, the superior performance of people who are overweight on strength exercises can foster positive outcome expectations **(**see **Chapter 2)**.

We previously proposed to combine these biological and psychological insights to argue in favor of exercises for people who are overweight or obese focusing on strength, suggesting that: (1) people who are overweight or obese are stronger (in the absolute sense) and better at (absolute) strength exercises compared with normal weight people; (2) strength exercises are easier for people who are overweight compared with aerobic exercises, and therefore compliance is greater; (3) people who are overweight may enjoy strength exercises, by being better at strength exercises than aerobic exercises than normal-weight people, facilitating long term behavior change; (4) strength exercises have beneficial effects on the body composition of people who are overweight or obese and thus on metabolic and cardiovascular health (see **Chapter 1 and 2)**.

As a first step towards considering strength exercises in health behavior change interventions targeting overweight and obesity, it is necessary to systematically map what is known about the differential psychological consequences of strength versus aerobic exercise. Strength training indeed has positive effects on body composition and health for people who are overweight or obese (Alberga et al., 2013), but the evidence for positive psychological effects is limited (e.g. Lubans et al., 2016) and still unclear at the moment (for an elaborate overview, see Lloyd et al., 2013; Schranz et al., 2014). In an earlier review by Schranz and colleagues (2013), the effects of strength training on strength, body composition and psychosocial status were examined in adolescents who are overweight or obese. In their review, four papers that focused on psychological outcomes were included, but in none of these four studies was the independent effect of strength training on psychological outcomes reported (i.e. two studies compared a resistance + aerobic + diet intervention with a diet intervention; one study examined the effects of a combined resistance + aerobic + diet + behavioral therapy intervention versus a no intervention control group, and one study examined the time effects of a combined resistance + aerobic + behavioral therapy intervention). Additionally, the limited number of studies, and conflicting findings prevented a definitive conclusion. The aim of the current systematic review was to assess the independent psychological effects of strength training or strength exercises for people who are overweight or obese.

Methods

Data sources and search strategy, study selection and data extraction

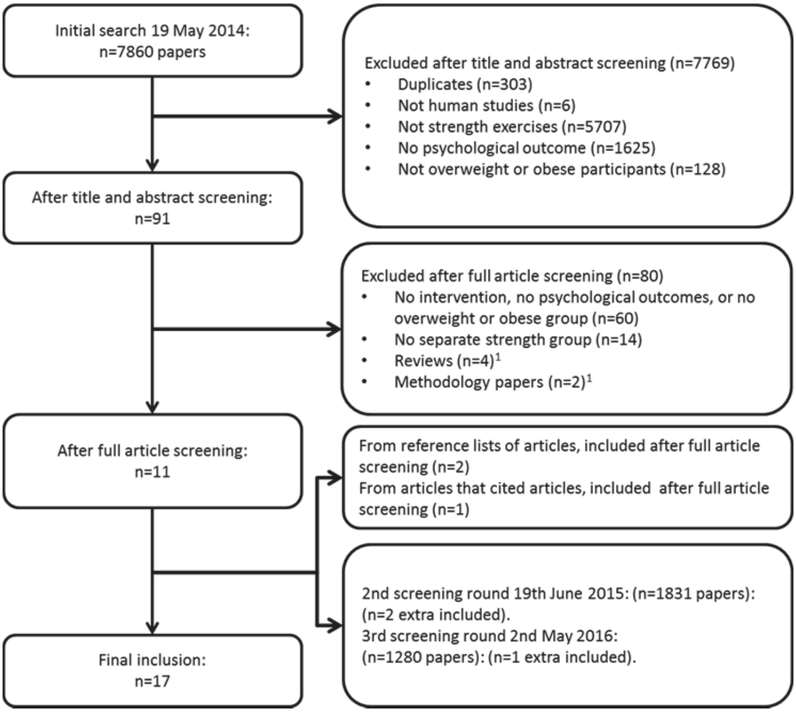
For the literature review, no restrictions were made regarding year of publication, language of the manuscript (although all manuscripts found were in English) or design of the study. Because of the expected limited number of studies in this specific area, three criteria were originally used for inclusion. Initially, we aimed to develop a search strategy to locate all studies in (1) people (all ages and both sexes) who are overweight or obese that reported the effect of (2) strength exercises on (3) at least one psychological construct. However, for the literature search, this last criterion turned out to be not feasible, because the psychological outcomes were too varied depending on the underlying theoretical concept. Given our aim of identifying any effects that strength exercises may have on psychological outcomes, it proved impossible to capture this last criterion in query terms without running a considerable risk of excluding potentially relevant literature. Therefore, we used the first two criteria and then selected papers that mentioned any psychological concepts, first based on title and abstract and later on full text (see Table 1). Only studies that reported the independent effect of strength training on psychological outcomes in overweight or obese people was included. No other restrictions were applied.

Table 1. Search terms

((overweig*) OR (obese) OR (obes*) OR (obesity) OR (overweight) OR (weight status) OR (adipos*))
AND
((strength*) OR (Strength) OR (resistance) OR (resist*) OR (weight-lifting) OR (weight lifting) OR (weight bearing) OR (weight-bearing)) AND ((program*) OR (intervention) OR (train*) OR (exercis*))

Relevant literature was identified by use of the PubMed and PsycINFO databases (first data search on 19th of May 2014). In the first screening round (N = 7860) two screeners (GH and GK) identified 14 papers that met the eligibility criteria (see Figure 1 for a flowchart showing the literature search progress). In a second and third screening round a total of 3 additional studies were found. The final number of included studies was 17. In the supplementary materials at http://focusonstrength.net, a detailed list of all initial paper titles and abstracts can be found, including why papers were systematically excluded, together with the PRISMA checklist (Moher et al., 2009)

.



[1] Reviews and methodology papers used for reference screening and screening of papers that referred to these papers (using Google Scholar).

Figure 1. Flowchart of the literature search progress

Study quality and categories

To acknowledge study quality and simultaneously take into account the intervention administered in the control group (De Bruin et al., 2009), we divided studies into five categories (see also Table 2). Studies in category I (a no-intervention control group compared to strength training) can answer the question whether strength training has an effect on psychological outcomes. Studies in category II (an active control group versus the same active control group plus strength training) can answer the question whether strength training has added value over and above the active control group intervention. Studies in category III (an active control group versus strength training) can answer the question how strength training performs compared to the active control group intervention (e.g., diet or aerobic training). Category IV (an active control group (e.g., aerobic plus diet) versus strength training plus another active component (e.g., diet)) can answer the question how strength training performs compared to a given active component, when both are combined with another active component. Category V (studies lacking a control group (i.e., pretest-posttest designs)) can provide very weak evidence for an effect of strength training over time, and was mainly included for the sake of completeness. To assess study quality, an additional risk of bias assessment was performed using the Effective Public Health Practice Project Quality Assessment Tool (Armijo-Olivo et al., 2012); see also the supplementary materials at http://focusonstrength.net.

Table 2. Study type categorization

Category	Strength training group		Comparison group	Example:		
I	Strength	*vs.*	Passive control	Strength training	vs.	No intervention Control
II	Strength + active control	*vs.*	Active control	Strength training + diet	vs.	Diet
III	Strength	*vs.*	Active control	Strength training	vs.	Diet
IV	Strength + active control I	*vs.*	Active control I + active control II	Strength training + diet	vs.	Diet + aerobic training
V	Strength	*vs.*	No control	Strength training	vs.	-

Measures of psychological outcomes

There was great variation in the psychological terminology used in the included studies. To establish which constructs could be aggregated, GH extracted the variables and their operationalization from the included papers.

To determine which psychological outcome measures could be aggregated, two authors (GK & GJP) indicated which construct they thought was being measured. To establish this, they consulted the papers' methodology sections where necessary. After this coding phase, two discussion rounds were conducted. In the first, both coders, facilitated by a third (GH), discussed the terminology used where there were minor deviations (e.g., one author used "mood (inverted)" and the other "negative mood", but the same variables were coded (90% consensus)). In the second discussion round, more fundamental differences were discussed and resolved. After consensus was achieved, the psychological outcomes were ordered into eight broad categories: disorders (e.g., anxiety and depression), inhibition, mood, outcome expectations, quality of life, self-efficacy, self-esteem, and stress (see the supplementary materials at http://focusonstrength.net). The resulting spreadsheet was then imported into R (R Core Team., 2016) for further analysis using metafor (Viechtbauer, 2010).

Analyses

For each study, effect sizes as well as corresponding variance estimates were extracted or calculated for the main effects of strength exercises on strength (as strength interventions are often focused on improvements in strength) and on psychological outcomes. Most studies used split-plot designs where within-subjects pre- and post-tests were combined with a between-subjects manipulation (see also Table 3). In such cases, computation of the effect sizes' variance estimates requires the correlation between pre- and post-test measures (Becker, 1988), which was not reported by any of the papers. We therefore computed three types of variance estimates, assuming correlations of 0.3, 0.5, and 0.7 (corresponding to the qualitative labels for effect size as tentatively suggested by Cohen, 1992). All analyses were therefore conducted thrice. The results for the correlation estimate of 0.3 will be reported, supplementing these reports with discussion of diverging outcomes where these occur.

Where studies reported multiple effect size estimates for variables that were coded as the same variable (e.g., "disinhibition" and "hunger" in Messier et al. (2010) were both coded as "inhibition (inverted)"), these were first aggregated to obtain one estimate per variable per study.

For these intra-study meta-analyses as well as the final between-study meta-analyses, random effects meta-analyses were conducted using the metafor package's restricted maximum-likelihood estimator (Viechtbauer, 2010). Heterogeneity was estimated using τ2 (estimated between-study variance), I2 (the proportion of variability in effect sizes due to heterogeneity rather than error), H2 (total variability compared to sampling variability) and Q (the χ2 test for heterogeneity), and forest and funnel plots were generated for each meta-analysis and are available in the supplementary materials at http://focusonstrength.net.

We identified 'positive effects' of strength exercises in people who are overweight or obese as occurring when psychological constructs changed in the desired direction (e.g., increase in self-efficacy or decrease in psychological distress).

Results

Study selection and general characteristics

In total, 17 studies were included in the systematic review (Figure 1). Based on our risk of bias assessment, the study quality of 13 papers was rated as 'moderate' and 4 papers were rated as 'weak' (see the supplementary materials at http://focusonstrength.net). Study characteristics are listed in Table 3. The number of participants in the different comparisons ranged from 32 (Davis, 2008) to 304 (Goldfield et al., 2015), with one extreme of 10,386 participants (Wicker et al., 2015). The intervention period ranged from an acute session of strength exercises (Levinger et al., 2009) to 48 weeks' training (Wadden et al., 1997). Seven studies included a comparison between strength training and a no-intervention control group (category I; see also Table 2 for examples). Eight studies included comparisons between an active control group (e.g., diet) and the same control group plus strength training (category II). Three studies compared strength training to aerobic training (i.e., an active control group – category III). One study compared strength training plus diet to aerobic training plus diet (category IV). Finally, three studies employed a pretest-posttest design (category V). Thirteen studies were in adults. All studies included a specific group of people who were overweight or obese (See Table 3).

Study outcomes: Psychological benefits

The 17 included studies had many different psychological outcomes. These are summarized in Table 4.

Based on the available data, for two studies (Waden et al., 1997; Ghroubi et al., 2009) no effect sizes could be calculated, and therefore, these were not included in the meta-analysis. One additional study (Levinger et al., 2007) was excluded for meta-analysis, as this study examined the acute effects of one strength exercise session. For all other studies effect sizes were calculated based on pre- and post-test means, standard deviations (SDs) and n-values in both the strength-exercise group and the comparison group. In one study (Lau et al., 2004) effect sizes were available. Study outcomes were divided into the five major study types and eight major outcome categories. All individual effect sizes, forest- and funnel plots can be found in the supplemental file at http://focusonstrength.net. Note that although the literature contained reports of the effect of strength training on eight different psychological variables, few studies were available for each

Table 3. Study characteristics.

Study	Study design: Strength component	Study design: Comparison	BMI Mean (SD)	Outcome (questionnaire)	n (F) age, y (range or [mean (SD)])	Study duration	Category[a]
Davis	Standard behavioral weight loss program + strength training	1) Standard behavioral weight loss program 2) Standard behavioral weight loss program + mindfulness	All: 32.9 (3.7)	Eating behavior , self efficacy for physical activity and weight loss, exercise beliefs, body image, mindfulness	71 (63) [25-39.9]	24 weeks	II
Fonzi	Standard behavioral weight loss program + home based strength training	Standard behavioral weight loss program	All: 33.3 (3.5)	Health related quality of life	48 (42) [18-55]	12 weeks	II
Ghroubi, et al.	Treadmill training + dietary advice + strength training	1) No intervention control 2) Treadmill training + dietary advice	All: 37.2 (5.2)	Psychological impact of obesity, quality of life	83 (70) [18-60]	8 weeks	II
Goldfield, et al.	1) Strength 2) Strength + aerobic	1) Aerobic training 2) No intervention control	All: 34.6 (4.5)	Body image, physical self-perceptions and global self-esteem, mood	304 (213) [14-18]	24 weeks	I, II, III
Lau, et al.	Dietary education and modification + strength training	Dietary education and modification	Intervention: 30.4 (4.7) Control: 29.0 (5.1)	Depression and anxiety	37 (25) [10-17]	6 weeks	II
Levinger, et al.	1) HiMF + strength training 2) LoMF + strength training	1) HiMF no intervention control 2) LoMF no intervention control	Intervention: 1) 31.6 (4.4) 2) 23.8 (3.1) Control: 1) 30.0 (3.7) 2) 24.3 (3.4)	Self perceived physical and mental quality of life	55 (27) [40-69]	10 weeks	I
Levinger, et al.	Acute session of strength training in 1) male non obese 2) male obese 3) female non obese 4) female obese	-	Group 1) 24.2 (0.9) 2) 31.0 (0.9) 3) 21.6 (0.8) 4) 30.6 (1.2)	Positive well-being, psychological distress and fatigue, health related quality of life	45 (23) [40-69]	Acute session of strength training	V

Table 3. Study characteristics (continued).

Study	Study design: Strength component	Study design: Comparison	BMI Mean (SD)	Outcome (questionnaire)	n (F) age, y (range or [mean (SD)])	Study duration	Category[a]
Levinger, et al.	1) HiMF + strength training 2) LoMF + strength training	1) HiMF no intervention control 2) LoMF no intervention control	All: 27.7 (0.7)	Depressed mood, physical health, mental health	55 (27) [40-69]	10 weeks	I
Martins, et al.	Strength training	1) No intervention control 2) Aerobic training	Intervention: 30.1 (4.6) Control 1) 29.0 (4.4) 2) 29.8 (4.4)	Mood states – depression, tension-anxiety, fatigue, vigor-activity, anger-hostility, confusion-bewilderment	78 (48) [65-95]	16 weeks	I, III
Messier, et al.	Caloric restriction group + strength training	Caloric restriction group	Intervention: 32.6 (4.9) Control: 32.2 (4.6)	Body esteem, self-esteem, stress, dietary restraint, disinhibition, hunger, quality of life, self-efficacy, perceived benefits, perceived risks	137 (137) [58 (5)]	25 weeks	II
Plotnikoff, et al.	Strength training	No intervention control	Intervention: 25.6 (7.8) Control: 38.5 (8.1)	Social cognitions	48 (32) [55 (12)]	16 weeks	I
Sarsan, et al.	Strength training	1) No intervention control 2) Aerobic training	Intervention: 33.73 (2.92) Control: 1) 35.54 (4.98) 2) 35.38 (4.98)	Ratings of mood	60 (60) [20-60]	12 weeks	I, III
Schranz, et al .	Strength training	No intervention control	Intervention: 32.2 (4.3) Control: 32.6 (5.0)	Self- efficacy, physical self-worth, self-esteem	56 (0) [13-17]	24 weeks	I
Wadden, et al.	1) Diet + strength training 2) Diet + aerobic + strength training	1) Diet 2) Diet + aerobic training	All: 36.5 (5.1)	Appetite, mood	128 (128) [41.1 (8.6)]	48 weeks	II, IV

Table 3. Study characteristics (Continued).

Study	Study design: Strength component	Study design: Comparison	BMI Mean (SD)	Outcome (questionnaire)	n (F) age, y (range or [mean (SD)])	Study duration	Category[a]
Wicker, et al.	Strength training	-	25.9 (4.74)	Satisfaction	10386 (7260) [46.4 (15.4)]	4 weeks	V
Williams, et al.	Strength training	-	33.1 (3.8)	Outcome expectancy, behavioral expectation, self-regulation, resistance training strategies, perceived satisfaction, intention	123 (91) [not stated]	24 weeks	V
Yu, et al.	Diet + strength training.	Diet	Intervention: 25.6 (3.2) 24.7 (3.0)	Physical self-concept	82 (28) [8-11]	6 weeks	II

BMI – Body Mass Index. SD = Standard Deviation, F = Female, HiMF – High metabolic risk factor. LoMF = Low metabolic risk factor.
[a] for category labels, see Table 2.

variable; and as the various studies provided data to answer different research questions, few studies were available for meta-analysis. This small number of studies for meta-analysis made heterogeneity hard to assess. Effect sizes seemed quite consistently heterogeneous for the exercises' effects on strength (see supplementary materials at http://focusonstrength.net). Heterogeneity varied from 0-100%, with *p*-values from <0.001 to 1 (See also the supplemental file at http://focusonstrength.net).

Table 4. Psychological outcomes per study.

Study	Intervention (resistance training group)	Comparison group	Psychological outcomes
Davis	R + Ae + D	Ae + D Ae + D+ mind-fulness	Eating behavior scores improved for all groups, without differences in groups. Intention to treat analyses show that the mindfulness group had greater scores compared to the standard behavioral weight loss program group. Mindfulness improved over time, but did not significantly differ between groups. Self-efficacy for physical activity when tired, when on vacation, and eating self-efficacy improved for all groups, but did not significantly differ between groups. Dietary restraint increased for all groups, without significant differences between groups. Body image improved over time for appearance evaluation, fitness orientation, health evaluation, health orientation, illness orientation, body-areas satisfaction, self-classified weight over time, and overweight preoccupation. Differences between groups were found only for health evaluation. In all groups a significant decrease in expected barriers for physical activity was found without differences between groups. A significant group x time interaction was found for the time barrier. Outcome expectations increased most in mindfulness and resistance training group. The mindfulness group had much higher expectations that body image will improve with exercise compared to the SBWL group.
Fonzi	R + Ae + D	Ae + D	No significant differences were found over time for social functioning, bodily pain, mental health, 'role emotional'. Significant increases were found for 'role physical', vitality, and general health (trend for physical functioning). No differences between groups were found.
Ghroubi, et al.	R + Ae + D	Ae + D No intervention	All stress test parameters improved in intervention groups but not in control group. Psychological status (anxiety, depression, and quality of life) improved in intervention groups but not in control group.
Goldfield, et al.	R R + Ae	No intervention Ae	Time, but no group x time, effects on body image Time, but no group x time, effects on anger and depression Significant effects on vigor (group x time) No effects on confusion, fatigue or tension Time, but no group x time, effects on self-perceived skills, and perceptions of physical self-worth Perceived physical condition, global self-esteem and strength were improved for the R&AE group vs control group
Lau, et al.	R + D	D	Non-significant improvement was found in anxiety or depression in both groups. No difference was found between the two groups for anxiety or depression.

Table 4. Psychological outcomes per study (Continued).

Study	Intervention (resistance training group)	Comparison group	Psychological outcomes
Levinger, et al.	R	No intervention	Training did not improve psychological outcomes in the LoMF group. Training increased perception of both physical and mental health in the HiMF group compared to the control group. Training improved scores on physical functioning, general health, social functioning in the HiMF training group. Self-perceived bodily pain got worse in the LoMF training group and improved for the HiMF training group. Self-perceived physical health improved more in the HiMF training group compared to the LoMF training group.
Levinger, et al.	R	-	In women, exercise increased positive well-being after exercise. Positive well-being in obese women tended to improve (p=0.059). Exercise did not change perception of psychological distress of fatigue in women (within and between). Fatigue increased after exercises more in non-obese men compared to obese men. No changes in positive well-being of psychological distress were found in men.
Levinger, et al.	R	No intervention	At baseline, no differences in depression scores between LoMF groups. The HiMF training group had a higher depression score at baseline compared to the HiMF control group. After training, depression score was improved in the HiMF training group compared to the HiMF control group (no such results were found in the LoMF groups).
Martins, et al.	R	Ae No intervention	Mood states changed over 16 weeks in the control group (more confusion) and strength training group (positive change in vigor). Furthermore, no differences were found after 15 weeks in depression, tension, fatigue, and anger.
Messier, et al.	R + D	D	Both groups improved for total body esteem, body esteem subscales, dietary restraint, disinhibition, hunger, quality of life subscale for health perceptions, and self-efficacy. No additional effects of resistance training on psychological factors were found.
Plotnikoff, et al.	R	No intervention	After 16 weeks resistance intention items significantly increased in the resistance training group compared to the control group. After 16 weeks scheduling self-efficacy was higher in the intervention group versus control. Task and barrier self-efficacy, and health related quality of life scores did not change significantly between groups. For individuals who completed at least 2/3 of the intervention, significant gains in task, schedule and barrier self-efficacy were found compared to individuals who completed less than 2/3 of the intervention.
Sarsan, et al	R	Ae No intervention	Both exercise groups improved in depression score. Only the aerobic exercise group changed significantly compared to the control group.
Schranz, et al .	R	No intervention	Significant differences were found between intervention and control group at 3 and 6 months in exercise self-efficacy. No significant differences between groups for resistance training beliefs (but large difference for the subscale confidence). Trends were found for physical self-worth (not statistically significant between groups). At 3 and 6 months, intervention group had higher global self-esteem compared to control group.

Table 4. Psychological outcomes per study (Continued).

Study	Intervention (resistance training group)	Comparison group	Psychological outcomes
Wadden, et al.	R R + Ae + D	D Ae + D	No significant differences among conditions at any time were found in changes in hunger, satiety, preoccupation with food, or intensity of food cravings. Mood changed over time in all groups. No significant differences among conditions were found in BDI scores. No significant differences among conditions in changes on any of the profile of mood states. In all conditions increases were found in vigor, and decreases in fatigue.
Wicker, et al.	R	-	Increases in life satisfaction Increases in health satisfaction
Williams, et al.	R	-	Resistance training intervention had significant effects on change in behavioral expectation, self-regulation, and perceived satisfaction but not outcome expectancies.
Yu, et al.	R + D	D	Confidence in strength increased significantly in both groups after intervention. The diet-and-strength training group increased significantly in self-concept of endurance compared to the diet-only group.

Ae: aerobic exercise intervention; BDI: Beck Depression Inventory; BMI: body mass index; D: Diet intervention; HiMF – High metabolic risk factor. LoMF = Low metabolic risk factor; R: Strength or resistance exercise intervention; SBWL: standard behavioral weight loss program.

The current state of the literature means that it is unclear how results from the meta-analyses should be interpreted. Therefore, the outcomes will be discussed qualitatively. We have, however, used the meta-analysis to generate diamond plots to aid interpretation of the current evidence base (Figure 2).

The diamond plots show that all effects are weak, but most of them are in a positive direction (i.e. strength training has a possible positive influence on psychological outcomes). Some weak effects emerged on self-efficacy, self-esteem and psychological disorders (e.g., anxiety and depression), but only compared to a no-intervention control group (first diamond plot [category I]). The second diamond plot (category II) shows that strength exercises have possible favourable additional effects on psychological disorders, self-esteem, and inhibition when combined with another active component, but that they are weak and have no additional effects on stress, self-efficacy, quality of life, or outcome expectations. In the third diamond plot, strength exercises were compared with other interventions (e.g., diet or aerobic exercises [category III]), showing that strength has possible positive effects on self-esteem but no stronger effects than diet or aerobic interventions on psychological disorders, quality of life, or mood. For the fourth study type (an active control group [e.g., aerobic plus diet] versus strength training plus another active component [i.e. diet]), no data were available (Wadden et al., 1997). For the fifth study type (pre-posttest design without a control group), positive time-effects for strength training were found for perceived well-being Levinger et al., 2009), health- and life satisfaction (Wicker et al., 2015), and behavioral expectation, self-regulation and perceived satisfaction (Lau et al., 2004). The study examining the acute effects of strength exercises showed some positive effects on well-being, but the results were inconclusive (Levinger et al., 2007). Subclassification by age (i.e. under 18 years and over 18 years) showed no clear differences in results (see the supplemental file at http://focusonstrength.net).

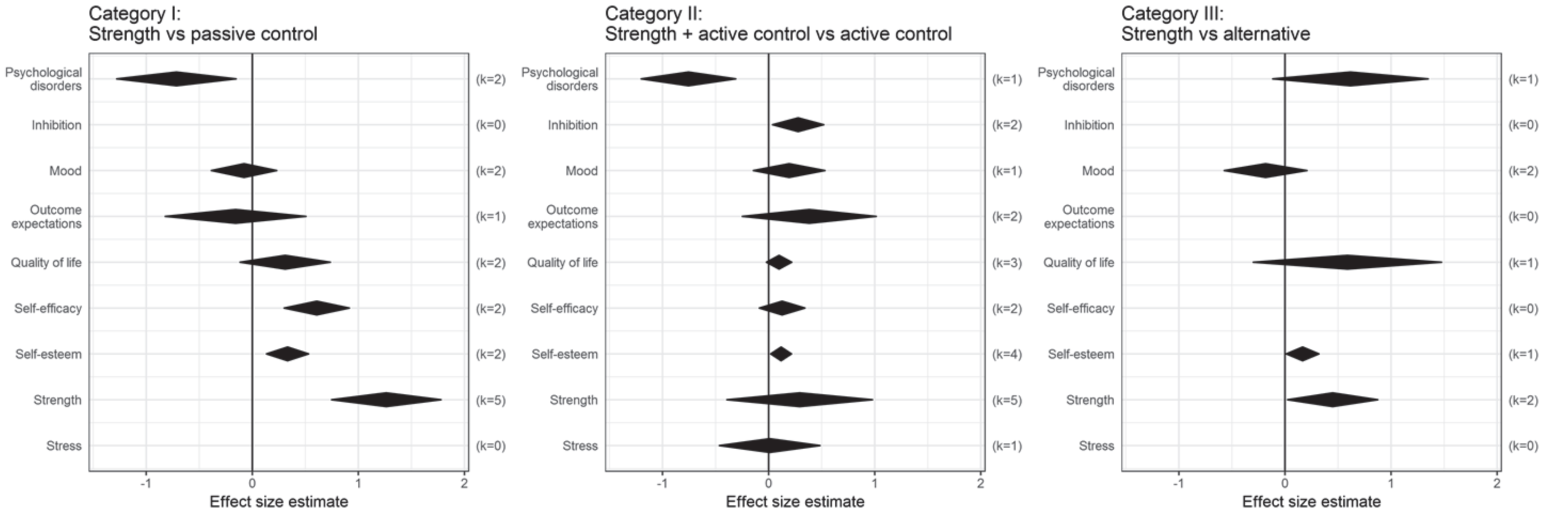


Figure 2. Effects of strength exercises on psychological outcomes: pooled effect sizes obtained from meta-analyses.

Discussion

In this systematic review, 17 studies were included, investigating the psychological effects of strength training in people who are overweight or obese. Strength training for people who are overweight or obese had small positive effects on various psychological outcomes when compared to a no-intervention control group, but these effects were often comparable to those of aerobic and diet interventions.

The various studies included in this review reflect a combination of high heterogeneity and a low number of existing studies. This reflects the unfortunate state of the literature, and is the main reason why our conclusions, despite our use of meta-analysis to aid interpretation, are tentative.

The two common responses to this combination of heterogeneity and low number of studies are 1) to conduct separate analyses to eliminate heterogeneity per analysis and 2) to combine outcome measures or study methodologies to maintain the number of studies in each analysis. It is difficult to conduct these responses at the same time and they are not reconcilable with each other. We therefore decided to report our analyses as they are. There is no evidence or theory to guide us to an 'objectively optimal' solution and given the current state of the literature, it will take some time before such guidance becomes available. The other consideration is that conducting multiple analyses sharply increases the probability of encountering statistical artifacts (e.g. making type 1 errors). We used a meta-analysis to generate diamond plots to aid interpretation of the current evidence base. In addition, we have provided the dataset (i.e. the extracted data), analyses and output. This will enable other researchers to separate/pool analyses as they see fit given their specific research interests.

Possible hypotheses for similar effects of strength exercises compared to other interventions on psychological constructs are 1) that the proportion of female participants in some studies was quite high, which might have impacted the results, 2) that for people who are overweight their main goal of participating in physical activity, dietary, or combined weight-loss interventions is generally to lose weight (Pescud et al., 2010), and 3) that the strength exercise component in some studies was limited: for example, in the study by Davis et al. (2008), participants were provided with strength exercise equipment and laminated exercise cards with descriptions of the strength training exercise that needed to be executed at home.

In strength training interventions, it is expected that people gain in muscular mass (lean mass), and therefore may not lose much weight despite a reduction in adipose tissue. Most studies in this systematic review reported that body strength improved after strength training compared to a no-intervention or other-intervention group, while body weight or body composition often did not differ significantly between a strength intervention group and comparison group(s). A first possibility for future studies might be to investigate the influence of giving feedback on body composition during strength interventions. Gaining strength, and ultimately obtaining a healthier body composition, might lead to a higher resting metabolic rate, increased total energy expenditure, and a decreased chronic diseases risk (Dixon, 2010). Thus, when participants in a strength training program become stronger, this should also lead to (long term) positive changes in body composition and health. However, these positive effects are often not reflected in reported short-term psychological outcomes of strength training as compared to other interventions.

Given that strength exercises performed similarly to alternative interventions, we might conclude that strength exercises are a viable alternative or addition to diet and/or aerobic interventions, but more research is necessary. Pescud and colleagues (2010) reported that feedback on body composition is useful as a 'surrogate' for feedback on weight loss, which motivated participants to continue participating in strength training exercises.

While body composition was reported in 10 out of 17 studies, none of these studies indicated that changes in body composition were given as feedback to the participants. As noted in the previous paragraph, giving feedback on body composition could be a form of positive reinforcement to engage in strength exercises. Also, the reported psychological outcomes were mostly clinical outcomes or markers of quality of life. None of the outcomes focused on self-determination, although self-determination concepts are very popular in motivation and intervention studies of exercise behavior (Teixeira et al., 2012). As we noted in our introduction, people who are overweight or obese may discover in a strength exercise program that they are stronger than normal weight people, which may result in their motivation for exercising to become relatively more intrinsic (see also **Chapter 1 and 2**). Measuring self-determination concepts as psychological constructs might give additional information about the effects of exercise training to be considered alongside that obtained from current clinical and quality of life measures.

The strengths of this systematic review are the focus on the independent psychological effects of strength training for people who are overweight, the use of meta-analysis, and the contribution to the available evidence for positive self-reported psychological effects of strength training. The weaknesses of this study relate to the limited range of psychological outcomes and the great variation in psychological terminology used in the included studies.

Conclusions

This review affords three conclusions. The first is that, indeed, strength exercises have possible positive effects on a number of psychological outcome measures in populations of people who are overweight or obese. The second is that these effects seem comparable to and sometimes stronger than those of aerobic and diet interventions. The third and main conclusion is that due to a lack of data both conclusions are provisional. There is a need for more research, and given the positive effects that can be expected based on theory and the promising patterns that seem present in the presently synthesized empirical evidence, the need is urgent. Future studies should include the effect of giving feedback on improved strength and body composition as motivators for strength training continuation, as well as measure additional psychological outcomes such as self-determination concepts.

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Chapter 4

A benefit of being heavier is being strong.

Ten Hoor GA, Plasqui G, Schols AMWJ, Kok G. A benefit of being heavier is being strong. (Submitted for publication).

Abstract

Objective: We hypothesize that heavier people are more positive about strength exercises, because they have more fat-free mass (FFM) and higher muscle strength. Further, we hypothesize that heavier people are better in strength exercises, and more positive about strength exercises compared to aerobic exercises.

Methods: In a cross-sectional study, height/weight, body composition, muscle strength, maximal aerobic exertion, and psychological determinants were measured in 68 participants (18-30years).

Results: Correlations between weight/BMI and FFM(index) (r's=.70-.80,p's<.001), FFM and muscle strength (r's=.35-.55,p's<.05), and muscle strength and attitudes/intentions/motivation for strength exercises were found (r's=.29-.43,p's<.05); BMI was related to psychological determinants via FFM and muscle strength. Participants with a higher BMI were better in strength exercises and more motivated to do strength exercises compared to aerobic exercises (p's<.05). Trends were found for attitudes and intention (p's<.1).

Conclusion: Strength exercises are more appreciated by heavier people and might be a valuable component in physical activity programs.

Introduction

Obesity is a worldwide problem with high costs to society and well-being (Alberga et al., 2013; Swinburn et al., 2011) Being physically active can prevent and decrease obesity (Heath et al., 2012), but is often challenging for people who are overweight or obese **(See Chapter 1, 2)**. In this study, we try to bridge the gap between biological and psychological insights in the management of obesity, by examining the putative physiological and psychological benefits of strength exercises for people who are overweight or obese **(See Chapter 1, 2)**. People who are overweight do not only have more fat mass but also more fat-free mass (Westerterp et al., 1995). With that, people who are overweight or obese are supposed to have more muscle mass, and to be stronger compared to people who are not overweight. Compared to aerobic exercises, strength exercises are easier for people who are overweight, and therefore compliance to an exercise program focused on strength exercises is greater (Faigenbaum et al., 2009). By being better in strength exercises than aerobic exercises, people who are overweight might be more positive about strength exercises compared to normal-weight people, and with that long-term behavior change may be achieved. Additionally, performing strength exercises has beneficial effects on overweight or obese people's body composition, and with that on their metabolic and cardiovascular health (Alberga et al., 2013). The main hypothesis is that 1) heavier people are more positive about strength exercises compared to normal weight people, because they have more fat-free mass and a higher muscle strength. Further, it is hypothesized that 2) people who are heavier are better in strength exercises, and more positive about strength exercises compared to aerobic exercises.

Methods

Following pleas for full disclosure (Peters et al., 2012; Simmons et al., 2011) all research materials and data are combined at http://focusonstrength.net. This study was approved by the Ethics Committee of the Maastricht University Medical Center+ (NL43929.068.13/METC 13-3-018).

Participants

A total of 70 participants (18-30 years of age) were recruited among students of Maastricht University. Two participants did not return on day 2 of the study, and were therefore excluded from the analyses. To get a better range in BMI and body composition, we advertised the study using flyers, including a statement that we were especially interested in students with a BMI>24. All participants were screened for good health using a medical questionnaire. Participants were excluded when they had any condition that prevented them from performing the exercise protocols (e.g. sports injuries or severe asthma). Prior to participation, written informed consent was obtained.

Procedure and measures

Participants that expressed their interest (by responding to the advertisement) and were found eligible (based on the medical screening questionnaire) were invited to visit the university on two days, with an 8-10 days interval.

For day 1, the participant was asked to refrain from any high intensity physical exercise 24 hours prior to the testing and to come to the laboratory in a fasted state (overnight fast). Height and weight of the participant was measured, and body composition was assessed using underwater weighing. Subsequently, participants were asked to eat a light breakfast (1 slice of bread with cheese). One hour after having eaten a light breakfast, cardiovascular fitness was assessed with a maximal exercise test (VO2max test) on a bicycle ergometer. Approximately one hour after the VO2max testing, the participant performed a familiarization session with the exercise equipment to estimate one-repetition maximum (1RM) strength. During the familiarization session, proper lifting techniques were demonstrated for leg press and chest press exercises.

At day 2, 8-10 days after day 1, the actual 1 repetition max (1RM) testing took place. Subsequently, the participant was asked to both perform a series of standardized strength exercise activities and standardized aerobic exercise activities (see: standardized exercise protocols). Directly after each exercise activity (both the strength and aerobic exercise), a questionnaire was filled out to measure social cognitive determinants (see: questionnaires).

After completion of both days, participants received a gift voucher and travel expenses. Participants from the Faculty of Psychology and Neuroscience at Maastricht University were able to choose between the gift vouchers, or participation credits (part of the Psychology bachelor curriculum) (See also Figure 1).

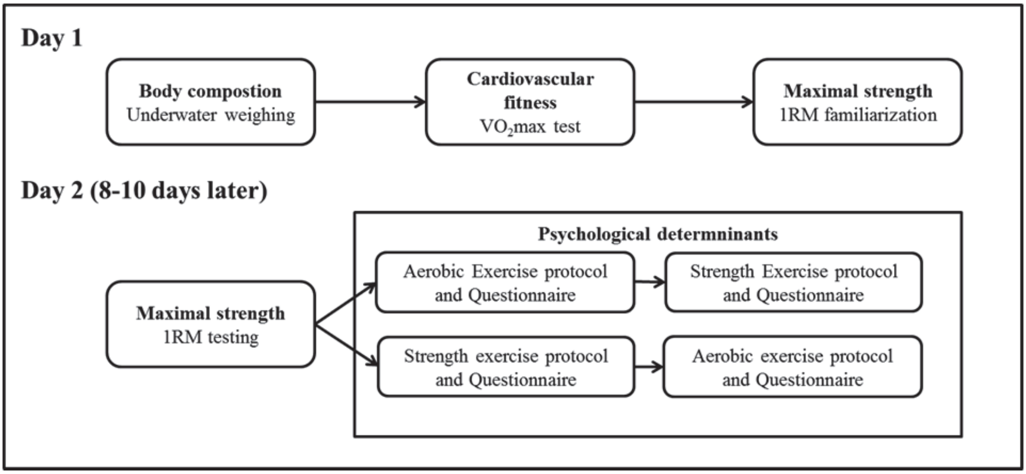


Figure 1. Flowchart of study protocol.

Body composition

Anthropometric measurements, body mass, and height were taken in the morning after an overnight fast. Body mass was measured on an electronic scale to the nearest 0.01 kg. Height was measured to the nearest 0.1 cm. Body volume was measured with underwater weighing with simultaneous measurement of residual lung volume using the helium dilution technique. Participants are completely submerged under water, for approximately 90 seconds to measure their weight under water, while breathing oxygen through a mouthpiece. The measurement was repeated three times. Body volume was calculated using the following formula: ((body mass$_{dry}$ – body mass$_{under\ water}$) / water density) – lung volume. Body density was derived from body weight and body volume, which was used to calculate fat mass and fat-free mass by Siri’s equation (Siri, 1961).

Maximal aerobic exertion test (VO2max)

Physical fitness was assessed with an incremental test on a bicycle ergometer using the protocol of Kuipers et al. (1985) During the test, oxygen consumption and CO2-production were measured continuously (Omnical, Maastricht University) and heart rate was monitored using a polar heart rate monitor (RS400, Polar Electro, Kempele, Finland). After a warming up of 5 min at 100 Watt (W) for men and 75W for women, the workload was increased with 50W every 2.5 min. When one's heart rate reached a value of 35 beats per minute (bpm) below the age predicted maximal HR (220 bpm - age) or the respiratory quotient (RQ= CO2-production/oxygen consumption) exceeded 1, workload was increased with 25W every 2.5 min until exhaustion. VO2max was presented relative to fat-free mass (ml/kg fat-free mass/min).

Maximal strength exertion test (1RM test)

Approximately one hour after VO2max testing, participants performed a familiarization session with the exercise equipment to estimate one-repetition maximum (1RM) strength. During the familiarization session, proper lifting technique was demonstrated for leg press and chest press exercises. Guided-motion exercise machines (one for leg press, one for chest press) were used to establish safe and proper lifting. Maximum strength was estimated in all participants using the multiple repetitions testing procedure (Mayhew et al., 1995). In a separate session, the actual 1RM testing took place. After warming up (5 min on light load on cycle ergometer), 2 sets of 12 repetitions were performed on the exercise machines at a light load (15 and 25 kg on the chest press, and 70 and 80 kg on the leg press, for female and male participants respectively). Next, the load was set at 95% of the estimated 1RM and one repetition was performed. Thereafter, the load was increased by 2.5–5.0 % after each successful lift until the participant was able to perform a maximum of one repetition (Verdijk et al., 2009).

Standardized exercise protocols

Standardized exercise protocols were carried out before each questionnaire. The order of the strength and aerobic fitness protocol was randomized to control for a possible order-effect. The strength protocol was based on the 1RM test. The 70% of maximal strength on the leg press exercise and chest press exercise was calculated. After a 5-minute warm up (75W; bicycle ergo meter), participants were asked to do three sets of 8-10 repetitions on the chest press apparatus, and three sets of 8-10 repetitions on the leg press apparatus. Between each set, there was a 2-minute break. Between the leg press and the chest press, there was a 5-minute transition time break. Also the order of the chest press and leg press was randomized to control for a possible order-effect.

During the VO2max, maximal heart rate and maximal workload was measured. After a 5-minute warm-up (75W, bicycle ergo meter), participants were asked to cycle for 10 minutes on 70% of their Wmax (70 rotations per minute; RPM), and to run 3x3 minutes at 70% of their maximal heart rate. Between the three sets of running, participants walked for 1 minute. Between the cycling and running there was a 5-minute transition time break. The order of the cycling and running was counterbalanced as well.

Questionnaires

A questionnaire, based on the Reasoned Action Approach (Fishbein & Ajzen, 2010) and the Self Determination Theory (Deci & Ryan, 2000), was filled out after having performed the strength exercise protocol and aerobic fitness protocol respectively (See also Table 1). In the first part of the questionnaires, specific questions were asked about the just performed exercises. In the second part, questions were asked about strength exercises and aerobic exercises in general. All items were rated on a 7-point Likert scale. Scores on items that measured the same construct were averaged into one scale where internal consistency was sufficient (α > .60). One item was deleted ('After doing this exercise, I'm satisfied no matter what my performance is') for both aerobic and strength exercises, as reliability analysis showed low scale reliability when this item was added to the intrinsic motivation construct. Scores were recoded such that a higher score reflected a higher value on the variable (see also Table 1 for the exact items and scoring).

Table 1. Questions after performing aerobic and strength exercises.

Determinant	S/G*	Questions	Rating [1 – 7]	α *aerobic*	α *strength*
Instrumental attitude	S	How good do you think this exercise is?	Very bad – Very good	.67	.84
	S	How healthy do you think this exercise is?	Very unhealthy – Very healthy		
	G	To me strength exercises are	Very unimportant – Very important		
	G	How useful do you think strength exercises are?	Not useful at al – Very useful		
	G	How healthy are strength exercises for you?	Very unhealthy – Very healthy		
Experiential attitude	S	How did the exercise feel?	Very unpleasant – very pleasant	.80	.89
	S	What did you think of the exercise?	Very boring – Very exciting		
	G	I think strength exercises in general are	Very unpleasant – Very pleasant		
	G	I think strength exercises in general are	Very boring – Very exciting		
Intention	G	I will do strength exercises in the future	Totally disagree – Totally agree	.96	.97
	G	I am planning to do strength exercises in the future	Totally disagree – Totally agree		
	G	I expect to do strength exercises in the future	Totally disagree – Totally agree		
Intrinsic motivation	S	The exercise I just did is something I would like to do in my free time.	Totally disagree – Totally agree	.83	.93
	G	I would like to do strength exercises in my free time	Totally disagree – Totally agree		
	G	I enjoy doing strength exercises	Totally disagree – Totally agree		
A-motivation	S	I am not made for this exercise	Totally disagree – Totally agree	.85	.83
	S	This exercise did not feel right for me	Totally disagree – Totally agree		
	G	I will never be good at strength exercises	Totally disagree – Totally agree		
	G	I am not suitable for strength exercises	Totally disagree – Totally agree		

*S =Specific, G = General, α = Cronbach's α. The shown questions for the general questions in this table are for the strength questions. The same questions were asked for aerobic exercises (i.e. the word 'strength' was replaced by the word 'aerobic'

Data analysis

IBM SPSS statistics and Excel were used to analyze the data. Frequencies (n), means (M) and standard deviations (SD) were calculated to provide an overall picture of the sample. Paired samples t-tests were conducted to calculate differences between male and female participants. Pearson's correlations were calculated to examine associations between the various determinants. We tested the direct and indirect associations linking BMI scores with associations with strength exercises using the PROCESS software including the bootstrapping method with bias-corrected confidence estimates (Mackinnon et al., 2004; Preacher & Hayes, 2004). Bootstrapping, a non-parametric sampling procedure, was used to assess the significance of indirect effects. In the present study, the 95% confidence interval of the indirect effects was obtained with 5,000 bootstrap resamples; results are statistically significant when 95% confidence intervals did not include zero. To compare correlations of BMI with strength and BMI with aerobic outcomes, first the difference in Fisher's z was calculated. Based on the z-score of this difference, p-values were estimated (Peters et al., 2008).

Results

A total of 68 participants participated in this study (BMI ranged from 18 – 38). Male (n=33) and female (n=35) participants did not differ in age, BMI, or VO2max (all p's >.05), but male participants were taller, heavier, and stronger. Female participants had a higher fat mass compared to male participants (see Table 2).

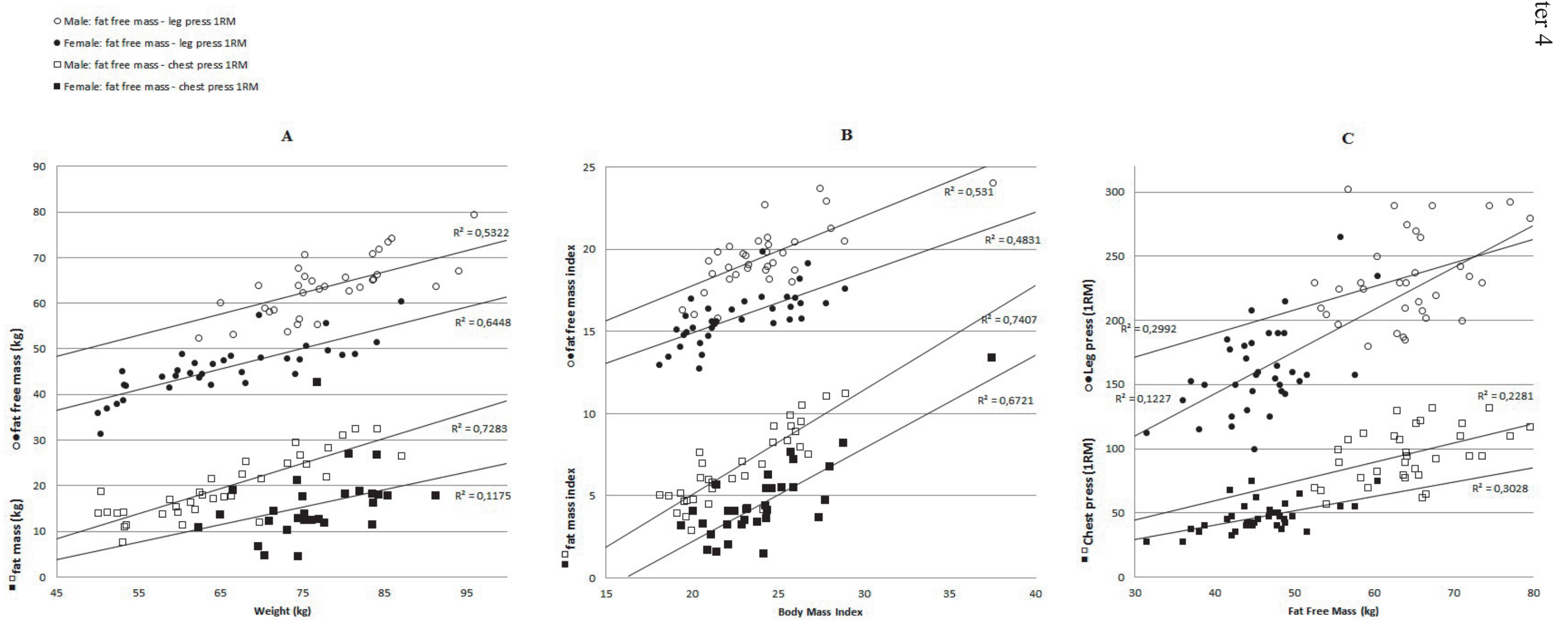
Table 2. Study sample characteristics.

	Total M(SD)	Male M(SD)	Female M(SD)	t(df)	*p*
N	68	33	35		
Age (years)	23 (3)	23 (3)	23 (3)	0.6 (66)	.51
Height (cm)	175.0 (8.4)	181.1 (6.1)	169.3 (6.0)	-7.9 (66)	<.001
Weight (kg)	72.0 (12.6)	79.2 (10.7)	65.2 (10.4)	-5.5 (66)	<.001
BMI (kg/m^2)	23.4 (3.2)	24.2 (3.3)	22.6 (3.0)	-2.0 (66)	.05
Fat mass (kg)	17.3 (7.3)	15.0 (7.3)	19.5 (6.7)	2.6 (66)	,01
Fat-free mass (kg)	54.6 (11.2)	64.2 (6.8)	45.7 (5.8)	-12.1 (66)	<.001
VO_2max (ml/min/fat-free mass)	54.3 (6.8)	55.0 (6.4)	53.6 (7.2)	-0.8 (66)	.40
Leg press (1RM)	196.8 (50.6)	234.2 (35.5)	161.4 (34.8)	-8.5 (66)	<.001
Chest press (1RM)	70.7 (29.9)	95.8 (21.4)	46.9 (11.9)	-11.6 (49)	<.001

Heavier means more fat-free mass, means stronger, means more fun

Correlational analyses revealed significant correlations between weight and fat mass (r= .85 for female and r = .78 for male participants, all p <.001), and BMI (weight adjusted for height) and fat mass index (fat mass adjusted for height; r= .86 for female and r = .82 for male participants, all p <.001; see Fig 2a). Weight and Body Mass Index (BMI) were also highly correlated with the fat-free mass and fat-free mass indices, respectively (r's ranging from = .70-.80, all p <.001; see Fig

Figure 2 Correlational analyses



2a. Correlations between weight and fat mass, and weight and fat-free mass for male and female participants separately.
2b. Correlations between BMI and fat mass index, and BMI and fat-free mass index for male and female participants separately.
2c. Correlations between fat-free mass and strength measures, for male and female participants separately.

2b). Participants with a higher fat-free mass had a significantly higher chest press 1RM (r= .55 for female and r = .48 for male participants, all p <.005), and leg press 1RM (r= .55 for female, p = .001 and r = .35 for male participants, p =.046; see Fig 2c). Finally, a combined strength score (sum of leg press 1RM and chest press 1RM) was positively correlated with instrumental attitude (r= .29 p = .02), experiential attitude (r= .31 p = .008), one's intention to start with strength exercises (r= .35 p = .02), and intrinsic motivation (r= .33 p = .007). An expected negative correlation was found with a-motivation (r= -.43 p <.001; See Table 3).

Table 3. Correlations between strength and psychological outcomes.

	Strength*		Strength*	
	r	*p*	*r* Female	*r* Male
Instrumental attitude (1-7)	.29	.02	.22	.32
Experiential attitude (1-7)	.32	.008	.31	.34
Intention (1-7)	.35	.003	.19	.37
Intrinsic motivation (1-7)	.33	.007	.23	.37
A-motivation (1-7)	-.43	<.001	-.29	-.46

*The strength measure is the sum score of chest press 1RM and leg press 1RM.

There was no direct effect of BMI on attitudes, intention, or motivations (p's range from .44 - .95; see Fig 3 and Table 4). Indirect effects of BMI on all psychological outcomes were found via fat-free mass and the combined strength score. No indirect effect from BMI to psychological outcomes was found via strength only. BMI had an indirect effect on experiential attitude (ß = -.08, SE = .05, CI SE = -.18 – -.01) and a-motivation (ß = .09, SE = .04, CI SE = .01 – .19) via fat-free mass (see Fig 3 and Table 4).

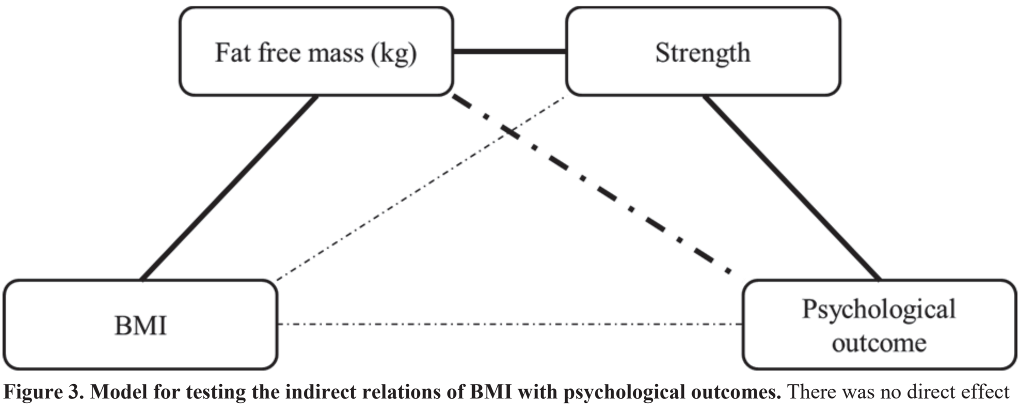


Figure 3. Model for testing the indirect relations of BMI with psychological outcomes. There was no direct effect of BMI on psychological outcomes, nor an indirect effect of BMI on psychological outcomes via strength. Limited indirect effects of BMI on psychological outcomes were found via fat-free mass. Significant effects of BMI on psychological outcomes were found when fat-free mass and strength were added to the model.

Table 4. Outcomes of the mediation analyses.*

	ß	*SE*	*CI SE*
Direct effect of BMI on psychological outcome			
Instrumental attitude	.03	.04	-.05 – .11
Experiential attitude	-.01	.05	-.12 – .10
Intention	-.00	.08	-.16 – .15
Intrinsic motivation	-.01	.08	-.14 – .16
A-motivation	-.02	.05	-.11 – .09
Indirect: BMI – fat-free mass –psychological outcome			
Instrumental attitude	.03	.02	-.11 – .01
Experiential attitude	**-.08**	**.05**	**-.18 – -.01**
Intention	-.04	.06	-.18 – .06
Intrinsic motivation	-.09	.07	-.25 – .01
A-motivation	**.09**	**.04**	**.01 – .19**
Indirect: BMI – strength – psychological outcome			
Instrumental attitude	.01	.01	-.00 – .05
Experiential attitude	.02	.02	-.01 – .08
Intention	.03	.03	-.01 – .10
Intrinsic motivation	.03	,03	-.01 – .10
A-motivation	-.03	.03	-.09 – .01
Indirect: BMI – fat-free mass – strength – psychological outcome			
Instrumental attitude	**.05**	**.03**	**.02 – .12**
Experiential attitude	**.10**	**.04**	**.04 – .21**
Intention	**.11**	**.05**	**0.2 – .25**
Intrinsic motivation	**.13**	**.06**	**.05 – .28**
A-motivation	**-.12**	**.04**	**-.23 – -.06**

*In bold the significant pathways.

Strength versus aerobic exercises

To examine whether heavier people are relatively better in strength exercises than aerobic exercises compared to lean people, correlations between BMI and strength outcomes and BMI and aerobic outcomes were calculated. Based on these correlations, a difference in Fisher's z was calculated and *p*-values were estimated (Peters et al., 2008) Comparing aerobic and strength variables shows that when participants have a higher BMI, they are significantly better in strength exercises compared to aerobic exercises (Fisher's z = .91, p <.001), more intrinsically motivated (Fisher's z = .46, p <.008), and less a-motivated (Fisher's z = .40, p <.02) for strength exercises compared to aerobic exercises. For the variables instrumental attitude, experiential attitude and intention, the directions of the relations were the same, but these variables were not significant (*p*'s ranged from .06 - .08) (see Table 5).

Discussion

We confirmed that heavier people have a higher fat-free mass compared to lean people. This is in line with biological insights (Westerterp et al., 1995). Additionally, we have shown that people with a higher fat-free mass are stronger (in absolute sense) and are better in strength exercises than aerobic exercises. We have also confirmed that mastery experiences (in this case, resulting from successfully engaging in strength exercises as opposed to aerobic exercises) are related to more positive psychological outcomes. This observation is in line with psychological insights (Bandura, 1986; Kelder et al., 2015; Suls et al., 2009; Van Knippenberg et al., 1981). As hypothesized, we have shown that heavier people are more positive about strength exercises compared to normal weight people, via fat-free mass and muscle strength. Moreover, heavier people are better in strength exercises, and are more positive about strength exercises compared to aerobic exercises.

Table 5. Comparison of correlations between BMI and aerobic variables, and BMI and strength variables.

		BMI	Fisher's z difference	*p*
	Max strength	.49	.91	<.001
	VO_2max	-.36		
Instrumental attitude	Strength	.20	.33	.06
	Aerobic	-.13		
Experiential attitude	Strength	.09	.30	.08
	Aerobic	-.21		
Intention	Strength	.15	.32	.06
	Aerobic	-.17		
Intrinsic motivation	Strength	.14	.46	.008
	Aerobic	-.31		
A-motivation	Strength	-.20	.40	.02
	Aerobic	.19		

To the best of our knowledge, this is the first time that this chain of relationships has been demonstrated empirically, thereby bridging the gap between biological and psychological insights. In light of these results, new exercise interventions for people who are overweight or obese could be developed concentrating on biological strengths, and using psychological principles and techniques to make them more aware of their strengths (see **Chapter 7**). Additionally, for long term behavior and health changes, new interventions might benefit from focusing (and giving feedback; Pescud, Pettigrew et al., 2010) on body composition instead of weight.

There are some limitations that should nuance the drawn conclusions. Most of the study participants are university students. The sample size is relatively small, but the used measures were accurate. The BMI range was limited, making more research necessary among a broader BMI range. Cross-sectional data instead of longitudinal data was gathered. With that, we were not able to show causality. However, most of our results were significant and in the right direction.

The definition of being 'heavier' is based on either a high weight or BMI, suggesting that someone is less healthy compared to someone with a normal weight or BMI. However, an increased weight or BMI is not a very reliable tool to evaluate body composition, and with that individual (metabolic) health (Bogin & Varela Silva, 2012). Therefore, to examine the statement 'heavier means more fat-free mass', we reported not only correlations of fat-free mass with weight, and fat-free mass index with BMI, but also correlations of fat mass with weight and fat mass index with BMI.

In conclusion, a benefit of being heavier is being strong. Strength exercise interventions might have the ability to make people who are overweight more motivated to be physically active in the long term. They might improve long term health by improving one's body composition (and energy balance, insulin sensitivity, blood pressure, cholesterol level, motor skills, and the chances on cardiovascular disease (Loyd et al., 2014; Paoli et al., 2015; Tibana et al., 2013; Vasquez et al., 2014). In short, strength exercises might contribute to the management of obesity. With interventions focusing on strength exercises the obesity problem per se will not be solved, but such programs might positively contribute to obesity related health issues.

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Chapter 5

Aerobic and strength exercises for youngsters aged 12 to 15: what do parents think?

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Abstract

Background: Although strength exercises evidently have both physiological and psychological health benefits across all ages, they are erroneously considered to adversely affect health status in youngsters. The aim of this study was to examine parental attitudes towards their child's physical activity in general, as well as aerobic and strength exercises in particular.
Methods: In total, 314 parents from an online panel representative of the Dutch population completed an online survey about their own physical activity and that of their child (12–15 years old). The study also explored reasons for non-participation, and attitudes about the parents' own and their child's physical activity level.
Results: Parents consistently reported a positive attitude towards aerobic exercises, but a less positive attitude regarding strength exercises. Parents were more likely to indicate that their child was not allowed to participate in strength exercises (29.6 %) than aerobic exercises (4.0 %). They thought that strength exercises could interfere with optimal physical development.
Conclusions: This study consistently shows that parents have a positive attitude towards aerobic exercises, but a less positive attitude regarding strength exercises. We suggest testing interventions to increase parental understanding of the advantages of and possibilities for (e.g., facilities) strength training on their child's health.

Background

Strength exercises have been shown to contribute to the prevention and reduction of obesity-related health problems (Lloyd et al., 2014). Strength exercises are defined as "exercises whereby an individual is working against a wide range of resistive loads to enhance health" (Lloyd et al., 2014, p1.) They have been shown to improve body composition (Alberga et al., 2013), decrease risk of developing chronic metabolic diseases (Dixon, 2010), and contribute to injury prevention (Lloyd et al., 2014). Psychological benefits have also been reported, e.g., improvements in self-concept (Lubans et al., 2010; Schranz et al., 2013), confidence (Pescud et al., 2010), mood (Lloyd et al., 2014), and quality of life (Levinger et al., 2007; 2009).

The idea that strength exercises for children and youngsters are detrimental for their health is outdated (Barbieri & Zaccagni, 2013; Faigenbaum & Myer, 2010; Lloyd et al., 2014). In the 1970s and 1980s, it was suggested that strength exercises are harmful for youngsters, particularly during growth, but there is compelling evidence that this is a persistent misperception, lacking in evidence (Barbieri & Zaccagni, 2013; Benjamin & Glow, 2003; Benson et al., 2008; Faigenbaum, 2007, 2010; Lloyd et al., 2014). In fact, more recently, the idea that strength exercises can be beneficial for youngsters (here defined as 12–15 year olds) is being embraced more and more (McGuigan et al., 2009; Sothern et al., 2000; see also **Chapter 1 and 2**).

We suggest that an important factor that may contribute to the relatively low participation of youngsters in strength exercises and strength-oriented sports is parental attitudes regarding these types of exercises. Parents play a crucial role in the physical activity-related behavior of their children (Maitland et al., 2013; Sleddens et al., 2012). They are largely responsible for the type and amount of physical activity that their child carries out, and are role models who influence their child's physical activity behavior (Bauer et al., 2011; Cleland et al., 2011). To develop and implement tailored physical activity interventions for youngsters it is important to identify parental attitudes about their children's participation in such exercises. We suggest that an important factor that may contribute to the relatively low participation of youngsters in strength exercises and strength-oriented sports is parental attitudes regarding these types of exercises. In this study, we investigated parental attitudes towards their own - as well as their child's - physical activities, including strength and aerobic exercises.

Method

Following pleas for full disclosure (Peters et al., 2012; Simmons et al., 2011), all research materials, data, analyses and output are available in a combined .zip archive that can be found at http://focusonstrength.net. This study was approved by the Research Ethics Board of the Faculty of Psychology and Neuroscience, Maastricht University, the Netherlands.

Participants

In order to include a minimum of 300 parents, 600 parents of 12–15 year olds were randomly invited via Flycatcher to participate in this study (Flycatcher has a normal response rate of approximately 50 %). Flycatcher, an online panel representative of the Dutch population (http://www.flycatcher.eu/; ISO 26362 and ISO20252; Dutch quality label, certifying that the panel can be used for social-scientific research), has 1300 registered parents of youngsters aged 12–15 years. After dropout (wrong e-mail address, $n = 10$; bad response, straight lining, or consistent patterns in answering; nonsense answers on open questions (e.g., typing random letters), $n = 23$), 314 parents completed the study (53.2 % response rate).

Procedure and measures

All participants provided informed consent prior to data collection. The questionnaire consisted of four parts: two parts about the parents themselves, and two parts about the children. First, general questions were asked about the parent's own physical activity behavior and their self-reported height (in centimeters) and weight (in kilograms). Subsequently, their attitudes with regard to engaging in physical activity were measured. In the third and fourth part of the questionnaire, similar questions were asked, but then in relation to their child's physical activity behavior and attitudes (we measured parental perceptions of their child´s activity and attitudes). Before answering the questions about their child, participants were instructed that all questions were about their youngest child in the age range 12 to 15 years. Questions were formulated by following the guidelines provided by Fishbein and Ajzen (2010).

Information about gender, age, and highest level of completed education (categorised into low – none, or primary education; medium – intermediate/high general secondary education or intermediate vocational education; high – college degree or higher) had already been collected by, and was available from Flycatcher. All items were rated on a 7-point Likert scale ranging from 1 (*completely disagree*) to 7 (*completely agree*), unless otherwise stated. Scores on items that measured the same construct were averaged into one scale where internal consistency was sufficient ($\alpha > .60$;Nunally & Bernstein, 1994). Scores were recoded such that a higher score reflected a higher or more positive value of the construct in question.

Physical activity behavior

The parents were asked whether they themselves are physically active, what kind of exercise(s) they perform, how often they engage in this type of exercise, the average amount of hours they engage in the exercise(s) per session, and their estimation of the type of exercise they engage in: 1- *aerobic*; 2- *a combination of aerobic and strength, mostly aerobic*; 3- *an equal combination of aerobic and strength*; 4- *a combination of aerobic and strength, mostly strength*; 5- *strength*. If the parent indicated that he or she did not engage in physical activity, we asked what the most important reason(s) for this was (were).

Next, questions about their child's physical activity behavior were asked (these were similar to the parent's own general questions). Additionally, two questions were asked about whether their child is allowed to participate in physical activities with an emphasis on aerobic activities, and whether their child is allowed to participate in physical activities with an emphasis on strength exercises. For both questions the response scale ranged from 1 (*absolutely not*) to 7 (*absolutely*). When the participant answered one of these questions with a score indicating that their child is not allowed to participate in either one of these types of exercises (score <5), we asked what the most important reason(s) for that decision was (were). Due to a malfunction of the online questionnaire, not all parents answered the question, "Is your child allowed to participate in exercises with an emphasis on aerobic components?" (66 missing values). For subsequent linear regressions, these were imputed by a random number based on the same mean score and standard deviation.

Parental attitudes about their own physical activity behavior

Parental attitudes about physical activity in general (5 items), strength exercises (5 items) and aerobic exercises (5 items) were assessed using the general attitude questions proposed by Ajzen and Fishbein (2010; further referred to as 'general attitudes'). All questions were rated on a 7-point Likert scale, i.e., *"I think my engagement in physical activity/strength exercises/aerobic exercises is very good – very bad; very important – very unimportant; absolutely not necessary – absolutely necessary; very unpleasant – very pleasant, very harmful – very harmless.* Cronbach's alphas for the scales ranged from .78 to .94.

Parental attitudes about their child's physical activity behavior

In order to assess (general) parental attitudes about their child's behavior, similar questions were asked as those regarding their own behavior. For items relating to their child, all questions started with, *"When my child participates in physical activity/strength exercises/aerobic exercises, or wants to participate, I think that is…"* Subsequently, more specific parental attitudes were assessed regarding their child's perceived abilities in terms of participating in the different types of exercises, whether they would allow and encourage exercise in their children, and norms and expectations (further referred to as specific attitudes). The exact questions can be found in Table 1.

Table 1. Specific questions about parental attitudes towards their child

Abbreviation	Specific attitudinal questions[a]
Possible	In my current situation, it's absolutely possible to let my child participate in aerobic/strength exercises
Facilities	There are enough facilities to let my child participate in aerobic/strength exercises
Fit/strong	My child is very fit/strong and healthy, and therefore my child does not have to participate in aerobic/strength exercises.
Worse/better	My child is (1) much worse – (7) much better at aerobic/strength exercises compared to other children of the same age and gender.
Enjoyable	Compared to other children of the same age and gender, my child thinks aerobic/strength exercises are (1) less enjoyable – (7) more enjoyable
Good	My child is good in aerobic/strength exercises
Allowed when wanted	When my child wants to, he/she is allowed to participate in aerobic/strength exercises.
Encouraged when wanted	When my child wants to participate in aerobic/strength exercises, I will encourage him/her.
Expectation	I expect my child to start participating in aerobic/strength exercises

Note. [a]All questions were asked about aerobic and strength exercises separately

Child and parental background factors

Various parental background factors were assessed. These included gender, age, and educational level (low - medium - high). Parents were asked to indicate their own weight and height, which was used to calculate parental Body Mass Index (BMI; in kg/m^2). For descriptive purposes, BMI values were categorised as underweight (BMI < 18.5), normal-weight (BMI ≥ 18.5 and BMI < 25), overweight (BMI ≥ 25), or obese (BMI ≥ 30). Parents were also asked to report their child's weight and height in order to calculate the child's BMI. The child's BMI was then recoded into age and gender-specific BMI z-scores and compared to the national reference population (Fredriks et al., 2000). A child's BMI z-score > 85th percentile was considered to indicate overweight, and a child's BMI z-score > 95th percentile was considered to indicate obesity (Barlow, 2007). BMI z-scores < −5 or > 5 were considered unrealistic and were not used for further analyses, as advised by the World Health Organization (De Onis et al., 2007).

Data analyses

IBM SPSS statistics 20 was used to analyse the data. Descriptive analyses - frequencies (*N*), means (*M*) and standard deviations (*SD*) – were calculated to provide an overall picture of the sample. Paired samples t-tests were conducted to compare general attitudes (regarding physical activity, aerobic, and strength exercises) towards the parents’ own exercise behavior and their general attitude towards their child performing these behaviors. In the same way, differences between specific attitudes towards aerobic and strength attitudes were examined. For two variables (“General attitude about child’s strength exercises”, and “Is your child allowed to participate in exercises with the emphasis on strength exercises?”) Pearson’s correlations were reported for parental and child demographics, behaviors, general attitudes relating to general physical activity and aerobic exercises, specific attitudes and parental assent (whether the parents allow their child to engage in aerobic exercises) (for interested readers: Spearman’s Rho can be found at http://focusonstrength.net). Only significant variables, with a p-value $< .001$ (to correct for multiple testing), were added into two separate linear regression models. The outcome variable of the first model was general parental attitude regarding their child’s strength exercise behavior. In the second model, parental assent (whether the parents allow their child to participate in strength exercises) was included as an outcome.

When the participant indicated that their child was not allowed to participate in aerobic or strength exercises, the most important reason(s) for that decision was (were) recorded. These (qualitative) data were divided into categories by two independent raters (GtH & ES). After this individual categorization process, definite categories were chosen by consensus. Frequencies and percentages of themes are reported.

Results

Characteristics of the study population are depicted in Table 2. Surveys were completed by an approximately equal number of mothers (43.6 %) and fathers (56.4 %). The majority of the participants reported medium or higher levels of education, with 45.2 % indicating that they had completed intermediate/high general secondary education or intermediate vocational education, and 32.5 % indicating that they had a college degree or higher. Gender of the children was also equally divided (48.4 % girls). The mean age of the children was 13.4 (±1.0 *SD*) years. With regard to weight status, 60.9 % of the parents were overweight (40.8 %) or obese (20.1 %) and for children these percentages were 12.0 % and 9.7 %, respectively. In general, parents reported that their children were more physically active (M_{child} = 319.1 min per week ($SD = 401.9$)) compared to themselves (M_{parent}=168.5 min per week ($SD = 272.4$)) $t(313) = -6.15$, $p < .001$.

Types of physical activity behavior and reasons for not being physically active

The majority of the parents reported that when they are physically active it tends to be characterised by aerobic exercise more than strength training (see Table 2). Parents identified the exercise of their children as ‘mostly aerobic’ (44.0 %). From the total sample, 38.9 % of parents were not physically active (no sport participation), as compared to 26.1 % of the children. Sixty-one percent of the inactive children (50 out of 82) had inactive parents.

Table 2 Background characteristics of the sample ($N = 314$)[a]

	Parent	Child
	M (sd)	**M (sd)**
Gender (Female:Male)	137:177	152:162
Age in years *(SD)*	45.8 (4.7)	13.4 (1.0)
Education level		
Low (%)	70 (22.3)	-
Medium (%)	142 (45.2)	-
High (%)	102 (32.5)	-
BMI (z) (*SD*)[b]	26.65 (4.51)	−0.05 (1.32)
Underweight (%)	4 (1.3)	36 (12.0)
Normal-weight (%)	119 (37.9)	199 (66.3)
Overweight (%)	128 (40.8)	36 (12.0)
Obese (%)	63 (20.1)	29 (9.7)
Physical activity in min/week (SD)	168.5 (272.4)	319.1 (401.9)
Aerobic exercise (%)	74 (38.5)	56 (24.1)
Mostly aerobic (%)	70 (36.5)	102 (44.0)
Both aerobic and strength (%)	38 (19.8)	62 (26.7)
Mostly strength (%)	9 (4.7)	11 (4.7)
Strength exercises (%)	1 (0.5)	1 (0.4)
No physical activity (%)	122 (38.9)	82 (26.1)

Note. 12 children had missing values for BMI/weight status; 2 children had an unrealistic BMI z-score (< −5) and were removed as advised by the WHO (De Onis et al., 2007). Type of physical activity behavior (ranging from aerobic exercise to strength exercise); percentages for type of exercise were calculated after removing the children that were not physically active (no sport); percentage from total sample was calculated for children that were not physically active (no sport)

[a]All values are *N*'s, unless otherwise indicated. [b] a BMI score was calculated for the parents; a BMI z-score was calculated for the youngsters

We asked whether parents allowed their child to perform physical activity with the emphasis on aerobic exercises ($M = 5.81$, $SD = 1.31$; range 1–7) or on strength exercises ($M = 4.32$, $SD = 1.67$; range 1–7). These numbers indicate that most parents were positive about aerobic exercise, but less positive about their child participating in strength exercises. Thirteen parents (4.0 %) indicated that they preferred their child not to participate in exercises with an emphasis on aerobic components. The most important reason for this (mentioned by 7 out of 13 parents) was that they considered other factors (such as fun) to be more important; two parents indicated that their child decides, one mentioned time as reason and 1 mentioned medical reasons. Many more parents indicated that their child was not allowed to participate in exercises with an emphasis on strength (93 out of 314; 29.6 %). Parents reported that they worried that exercises with an emphasis on strength components were bad for their child's health ($n = 46$; injuries and physical development). Additionally, parents believed that aerobic exercises, team exercises and fun were more important, ($n = 27$), or indicated that they thought strength exercises were not necessary for their child's health ($n = 21$). Also, a small group ($n = 8$, of which 6 had daughters) thought that strength training was not appropriate for their child's appearance (i.e., body builder image/activities that are seen as masculine). Other reasons mentioned included time, costs, and their child deciding for him/herself (see Fig. 1).

Differences in attitudes of parent vs. child towards aerobic vs. strength exercises

As compared to their own general attitudes regarding types of physical activity behaviors (i.e., aerobic, strength, or a combination of both), parents reported more positive attitudes about their child's physical activity in terms of general and aerobic exercise (see Table 3). No such difference was found with regard to strength exercises. Moreover, parental attitudes towards strength exercises were significantly more negative (all *p*'s < .001). Analyses for daughters and sons separately, or mothers and fathers, all showed comparable results (not reported; see http://focusonstrength.net).

Table 3.Differences in general parental attitudes with regard to their own and their child's exercise behavior (*N* = 314)

		Parent	Child	t (df)	*p*
		M (sd)	**M (sd)**		
General attitude (1–7)	Sport	5.33 (.96)	5.87 (.87)	−11.84 (313)	< .001
	Aerobic	5.18 (1.02)	5.54 (.94)	−6.78 (313)	< .001
	Strength	4.09 (1.10)	4.03 (1.33)	.83 (313)	.41

We conducted an independent samples *t*-test to see whether there were differences between the specific attitudes regarding aerobic and strength exercise. All parents had more positive scores for aerobic as compared to strength exercise (see Table 4). Again no differences in outcomes were found when analysing the data in gender sub-groups.

Table 4 Differences in specific parental attitudes with regard to aerobic and strength exercise behavior of their child (*N* = 314)

Determinant (1–7)	Aerobic	Strength	t (df)	*p*
	M (sd)	M (sd)		
Possible	5.36 (1.53)	4.20 (1.82)	−11,76 (313)	< .001
Facilities	5.54 (1.37)	4.74 (1.66)	−9,87 (313)	< .001
Fit/strong	3.63 (1.63)	4.39 (1.55)	−8,35 (313)	< .001
Worse/better	4,58 (1.33)	4.15 (1.16)	−5,85 (313)	< .001
Enjoyable	4,42 (1.31)	3.61 (1.30)	−9,62 (313)	< .001
Good	4,73 (1.45)	4.26 (1.35)	−5,69 (313)	< .001
Allowed when wanted	5,82 (1.08)	4.82 (1.38)	−12,50 (313)	< .001
Encouraged when wanted	5,75 (1.02)	4.33 (1.46)	−16,96 (313)	< .001
Expectation	4,74 (1.62)	2.88 (1.54)	−18,35 (313)	< .001

Note. Please note that the specific questions belonging to the constructs above are described in Table 1

Attitudinal correlates of strength exercise behavior

Pearson's correlations were reported for parental and child demographics, behaviors, general attitudes about general physical activity and aerobic exercises, specific attitudes and parental assent (whether parents allowed their child to engage in aerobic exercises). Only significant variables, with a *p*-value < .001 (to correct for multiple testing), were added into two separate linear regression models. The outcome variable of the first model was general parental attitude regarding their child's strength exercise behavior. In the second model, parental assent (whether parents allowed their child to engage in strength exercises) was included as an outcome. Pearson's correlations and regressions are reported for parental and child demographics, physical activity behaviors, general and specific attitudes about physical activity, strength and aerobic exercises,

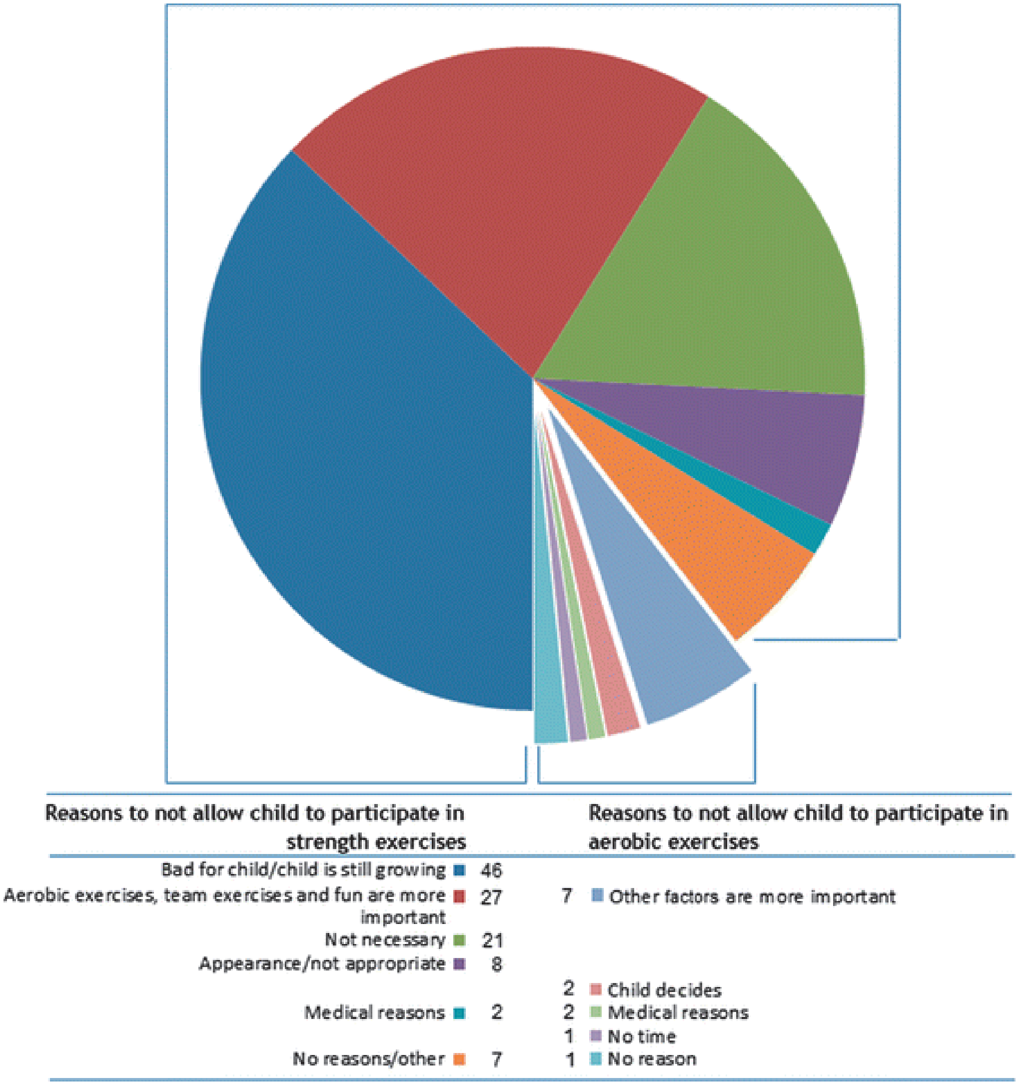

Fig. 1. Parental reasons for not allowing their child to participate in exercises with an emphasis on aerobic and resistance components

and parental assent (whether they allowed their child to engage in aerobic exercises), see Table 5. We reported correlations and regressions in one table, because the betas are sensitive to intercorrelations among the predictors. We first describe correlations, then report linear regression model 1, and finally regression model 2. Parents' general attitudes about their child's strength exercises were neither positive nor negative (M = 4.03 on a scale from 1 to 7). Of the variance in general attitude regarding the child's strength exercise behavior, 60 % could be explained by the variables in our model. The highest correlation was with the parental assent (whether they allow their child to participate in strength exercises) ($r = .68$). Most variance was explained by general parental attitude towards strength exercises, $\beta = .44$ ($r = .55$), parental encouragement when their child wants to participate in strength exercises, $\beta = .37$ ($r = .65$), and whether the parents allow their child to participate in strength exercises when the child wants to, $\beta = .05$ ($r = .52$). In addition to these determinants, parental estimations of whether their child enjoys strength exercises has made a significant contribution to the regression $\beta = .13$ ($r = .40$).

Of the variance of the parental assent (whether the parents allow their child to engage in strength exercises), 46 % could be explained by the determinants. Most variance was explained by parental encouragement when their child wants to participate in strength exercises, $\beta = .35$ ($r = .60$), whether the parents allow their child to participate in strength exercises when the child wants to, $\beta = .21$ ($r = .55$), and whether the parents allow their child to participate in aerobic exercises, $\beta = .21$ ($r = .42$). Other significant contributions were parental attitudes towards their own strength exercise behavior, $\beta = .12$ ($r = .32$), and whether the parents thought that their child enjoys strength exercises, $\beta = .11$ ($r = .31$). Sensitivity analyses, where we ran the same statistical tests using only the parents with complete data revealed no difference in results from the analyses including the imputed values (r^2 = .62, and .47 respectively; data not shown).

We selected parents ($n = 46$) who indicated that they think strength exercises are bad for their child, *and* indicated that their child was not allowed to participate in strength exercises (M = 2.65). We examined whether these parents would allow their child to participate in strength exercises if their child wanted to. Mean scores indicated that under that condition parents were neutral about their child's participation in strength exercises (M = 3.73), and less negative about their own encouragement (M = 3.02). However, they did not expect their child to enjoy strength exercises (M = 3.18).

Discussion

Parents' attitudes about child physical exercise

The literature on parents' attitudes about their child's exercise is limited, but indicates that there is a positive relation between parental attitudes and exercise behavior of children (Anderson et al., 2009; Kimiecik & Horn, 1998). These studies do not distinguish between aerobic and strength exercises. Our study consistently shows that parents have a positive attitude towards aerobic exercises, but a less positive attitude regarding strength exercises. Interestingly, when parents were asked to outline the reasons why they are negative about their child doing strength exercises, most mentioned (incorrectly) that such exercises are bad for their child, and that aerobic exercises, team exercises and having fun are more important. Please note that we only asked parents who did not allow their child to participate in strength exercises about their reasons for non-participation. As parental attitude about child strength exercises was most highly correlated with parental assent

Table 5 Determinants of parental attitude about their child's strength exercise behavior and parental assent (whether or not they allowed their child to engage in strength exercises

	General attitude about child's strength exercises ($N = 314$)			Is your child allowed to participate in exercises with the emphasis on strength exercises? ($N = 314$)		
Determinant	***r***	***β***	**CI (95 %)**	***r***	***β***	**CI (95 %)**
Age parent	-.11	-		-.03	-	
Age child	-.01	-		.05	-	
Gender parent (1 = M)	.06	-		.02	-	
Gender child (1 = M)	-.02	-		.02	-	
BMI parent	-.03	-		-.002	-	
BMI z-score child	-.16*	-		-.10	-	
Parent exercise (minutes/week) ($n = 192$)	.13	-		.13	-	
Child exercise (minutes/week) ($n = 232$)	-.06	-		-.03	-	
Kind of exercise parent ($n = 192$)[a]	.25*	-		.21	-	
Kind of exercise child ($n = 232$)[a]	-.06	-		.02	-	
Parental assent strength exercises child	.68**	NA		-	-	
Parental assent aerobic exercises child	.26**	.02	-.08, .12	.42**	.21**	.10, .24
Parental Attitudes about physical activity						
Attitude about parent physical activity	.24**	-.07	-.27, .08	.12	-	
Attitude about child physical activity	.15*	-		.10	-	
Attitudes about strength exercises						
Attitude about parent strength exercises	.55**	.44**	.39, .64	.32**	.12*	.04, .33
Attitude about child strength exercises	-	-		.68**	NA	
Possible	.30**	.07	-.02, .11	.30**	.09	-.001, .16
Facilities	.14*	-		.16*	-	
Fit/strong	-.15 *	-		-.07	-	
Worse/better	.20**	-.07	-.21, .06	.19*	-	
Enjoyable	.40**	.13*	.02, .24	.31**	.12*	.02, .29
Good	.23**	-.01	-.13, .11	.20**	.07	-.11, .13
Allowed when wanted	.52**	.05	−08, .18	.55**	.19*	.06, .40
Encouraged when wanted	.65**	.37**	.20, .47	.60**	.35**	.22, .57
Expectation	.42**	.003	-.09, .09	.29**	-.06	-.18, .05
Attitudes about aerobic exercises						
Parental attitude about aerobic exercises	.24**	.005	-.17, .18	.12	-	
Child attitude about aerobic exercises	.21**	.12	.01, .32	.12	-	
Possible	-.07	-		.003	-	
Facilities	-.06	-		.04	-	
Fit/strong	.01	-		.04	-	
Worse/better	.10	-		.11	-	
Enjoyable	.10	-		-.004	-	
Good	.08	-		.06	-	
Allowed when wanted	.07	-		.19*	-	
Encouraged when wanted	.07	-		.15*	-	
Expectation	.06	-		-.003	-	
Adjusted R^2		.60			.46	

Note. *$p < .01$; ** $p < .001$; only correlates with $p < .001$ were added in the linear regression model. [a]Kind of exercise: parents own estimation of the kind of exercise *(1 aerobic – 5 strength);* NB: The variable "is your child allowed to participate in exercises with the emphasis on strength exercises?" was not included as a predictor for "General attitude about child's strength exercises" and vice versa

(wether or not parents allowed their child to participate in strength exercises), most of the reasons for non-participation will be accounted for by those parents (who did not allow their child to participate in strength exercises). However, parents who do allow their child to participate in strength exercises may also consider reasons for non-participation. In future research these reasons should also be identified.

One limitation of our study is that besides asking questions about their own behavior and attitudes, we also asked the parents to supply information about their child's behavior and attitudes.

Parental estimations of their own and their child's physical activity behavior was not optimally measured in this study and, ideally, more objective measures of physical activity behavior should be used (see also De Bourdeaudhuij et al., 2005). However, we were more interested in the relationships between variables than their absolute values. Moreover, it is unknown whether the children would describe their own behavior in a similar way or differently. However, the focus of this study was on parents and in particular parents' attitudes regarding strength training in their children. Parents who were negative about allowing their child to participate in strength exercises reported that they would be less negative if their child wanted to participate in those exercises. These parents also indicated that they did not think their child would like such exercises. However, these parents may never have discussed strength exercises with their child. Parents may not relate strength exercises with improving health or with fun (**See Chapter 1 and 2**). For the parents who indicated that they did not want their child to participate in strength training, the most important reasons were related to *negative* consequences for their child's health. The data also showed that their idea of strength training was that it does not involve aerobic components, team play, and fun.

Implications for interventions

In conclusion, this study shows that parents are more positive about aerobic exercises as compared to strength exercises for their child. When developing interventions that encourage the use of strength exercises in youngsters, an important target group to focus on is the children's parents. Parents have a crucial role to play in children's physical activity-related behavior (Maitland et al., 2013; Sleddens et al., 2012). We suggest testing interventions to increase parents' understanding of the advantages of and possibilities (e.g., facilities) for strength training and the benefits of strength exercises on their child's health.

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PART III
THE DEVELOPMENT OF AN INTERVENTION

Chapter 6
Test-retest reproducibility and validity of the back-leg-chest strength measurements.

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Abstract

Background: A single measure to characterize overall muscle strength is advantageous because it saves time and costs of evaluation. For this reason, the back-leg-chest (BLC) strength might be an appropriate single measure in characterizing total body strength.

Objective: To assess the test-retest reproducibility and smallest real difference (SRD) of the BLC dynamometer in healthy adults and adolescents and to examine whether handgrip, knee-extensor and knee-flexor strength predict BLC strength in healthy adults.

Methods: Forty-five adults and 58 adolescents were recruited. In a first session BLC strength, handgrip strength, and additionally, in adults, isometric knee-extensor strength, and knee-flexor strength were measured. In a second session, 2-5 days later, BLC strength was measured again for test-retest reproducibility.

Results: Inter-session correlations of BLC strength were high (all r's and ICC's > 0.92). Bland-Altman-plots showed high agreement. The SRD and SRD% were between 14-26, and 19% and 26% respectively. Strength variables (handgrip, knee-extensor, and knee-flexor strength) explained 87% of the variance in BLC strength. A stepwise linear regression showed that dominant-knee extensor and flexor strength were the most important significant predictors of BLC strength ($r2 = 0.86$).

Conclusions: This study demonstrated that the BLC dynamometer has reasonably high test-retest reproducibility and hence may serve in some pertinent situations to be an appropriate tool for clinical, basic and applied research.

Introduction

Skeletal muscle strength is fundamental for physical performance (Brill et al., 2000) and health (Bohannon, 2008a; Ortega et al., 2008). Assessment of muscle strength is commonly used in physical examinations to determine possible impairments and physical disabilities, or in experimental settings to examine the effects of interventions. Therefore, it is important to have simple, valid, and reliable instruments to measure strength. Muscle strength is typically measured using dynamometry; it is based on having a person exert maximal resistance (force) against a continuously moving (isokinetic) or an immovable (isometric) mechanical lever, using a single muscle or a muscle group. Dynamometry is highly efficient for both clinical and research purposes (Abbatecola et al., 2005; Abernethy et al., 1995; Drouin et al., 2004; Fess, 1986; Mathiowetz et al., 1984), and is often used to validate other strength assessment techniques (Dolny et al., 2001; Neil et al., 2013; Taylor & Fletcher, 2013). However a disadvantage of some dynamometers is that they may be too expensive and/or impractical for some clinical settings. The most frequently used dynamometer is the handgrip dynamometer because of its cost effectiveness, simplicity and portability (Fess, 1987). However, the movement patterns performed during the execution of the handgrip test are not comparable to movement patterns of larger muscle groups, or performed in daily life or exercise training programs (Abernethy et al., 1995). To overcome this limitation, the BLC dynamometer might be an effective, simple and portable way to test total body strength. The BLC dynamometer is a device that measures isometric force produced together by the back, leg and arm muscles. Bethards and colleagues (Bethards et al., 1995) studied test-retest reproducibility of the BLC dynamometer in adults and reported reliabilities of 0.97 or higher, depending on the body position during the test. Moreover, both hand grip strength (HGS) and knee extensor strength (KES) were shown to be related to overall muscle strength (Abbatecola et al., 2005; Bohannon, 2009, 2012; Felicio et al., 2014; Rantanen et al., 1999) and have therefore often been used to indicate overall limb muscle strength (Bohannon, 2008b, 2009; Hosler & Morrow, 1982). Findings by Bohannon (2008a) suggest that even though HGS and KES can be used as an indicator for overall limb muscle strength in healthy adults, using these measures solely is not fully recommended in characterizing overall limb muscle strength. A single measure to characterize overall muscle strength is advantageous because it saves time and costs of evaluation. For this reason, BLC dynamometer might be an appropriate alternative single measure in characterizing overall limb muscle strength. Therefore the purpose of this study was twofold: first to examine test retest reproducibility and smallest real difference (SRD) of the BLC dynamometer in healthy adults and adolescents and second, to examine whether HGS, KES and knee flexor strength (KFS) predict BLC strength in healthy adults.

Methods

Subjects

To investigate test-retest reproducibility of the BLC dynamometer, 45 healthy adults (18–35 years; 23 female) among students and staff of Maastricht University, and 58 healthy adolescents (12–15 years, 30 boys, 28 girls) from a high school in the Netherlands were recruited. Participants with pathologies or disorders compromising the ability to perform maximal strength exercises were excluded. Before participation, informed consent was obtained from all volunteers (and for the adolescents also from the parents). This study was approved by the Research Ethics Board of

Faculty of Psychology and Neuroscience, Maastricht University (ECP-05-09-2012-A1), and conforms with The Code of Ethics of the World Medical Association (Declaration of Helsinki), printed in the British Medical Journal (18 July 1964).

Measurements and procedures

The measurements in the adult population took place in the movement-lab of Maastricht University, whereas the measurements with adolescents took place at the sports-ground of a Dutch high school. For this reason, KES and KFS, measured by the Biodex (Biodex medical systems, Shirley, NY, USA), were only examined in adults. All test procedures were instructed by the same investigator. All adults did a 5-minute warm up on a cycle ergometer, at 60 rotations per minute and a self-selected resistance. The adolescents warmed up by jogging at a self-selected speed. Subsequently, the test sequence started with BLC strength testing, to ensure that the BLC strength test results would not be affected by the Biodex and handgrip measurements. Values of the BLC strength, HGS, and in adults also KES and KFS were obtained on the same testing day (session 1) with three minutes of rest between the measures. In order to determine the test-retest reproducibility of the BLC strength, the test procedure of the BLC dynamometer was repeated for each participant two to five days after the first test occasion, approximately at the same time of day (session 2). Individuals were asked to abstain from intense physical activity in the two days prior to testing, and between the two test sessions, which were 2–5 days apart.

Height and weight Height (in cm) and weight (in kg) were measured using a SECA 761 analogue scale and a SECA 213 portable stadiometer (SECA Ltd. Medical Scales and Measuring Systems) with participants wearing light clothing without shoes.

Back-leg-chest strength A calibrated BLC dynamometer (Baseline, New York, USA; see Fig. 1) measures isometric muscle strength, recorded in kilograms (kg) and pounds (lb) of force. When an external force is applied to a handle, which is attached to an adjustable chain, a steel spring compresses and a pointer moves. The dial ranges from 0 to 300 kg (0 to 660 lb) in 10 kg (10 lb) increments. For the test, the length of the chain was adjusted to the participants' height by asking the subject to stand on the base of the BLC dynamometer with extended knees. Subsequently, the handle was positioned at the height of the intra-articular space of the knee joint. For the test, participants had to stand on the base, with knees and hips flexed slightly while the lower back had to maintain an appropriate lordotic curve. Subjects were asked to lift in a vertical direction by providing continuous isometric contractions of the extensors of the knees, hips, and lower back while holding the handle. Participants were asked to increase the pull in a safe manner gradually and reach the maximal force in three seconds, while keeping this pull for another two seconds. After demonstration and a familiarization trial, three trials were performed, with rest periods of 30 seconds between trials. Maximal strength for the three trials was used for further analysis.

Handgrip strength Dominant and non-dominant HGS was measured using the Jamar hydraulic hand dynamometer. The Jamar handgrip dynamometer is a portable device that measures HGS in kilograms and pounds with increments of 2 kg (or 2.5 lb). Isometric HGS was measured according to the American Society of Hand Therapists (Fess, 1992). In short, the participants sat in a chair without arm rests. The shoulder remained at 0◦ flexion, abduction and rotation, the elbow was flexed at 90◦ and wrist was positioned between 0◦ and 30◦ dorsi-flexion and between 0◦ and 15◦

of ulnar deviation. First, a demonstration and a familiarization trial were given for each arm. Then, the participants were instructed to continuously squeeze for 3–5 seconds for three trials, with a 30 second rest period between trials. The maximum value of the three trials was used for further analysis. Testing order (dominant/non-dominant) was balanced. The dominant hand was determined by asking the participants with which hand they write.

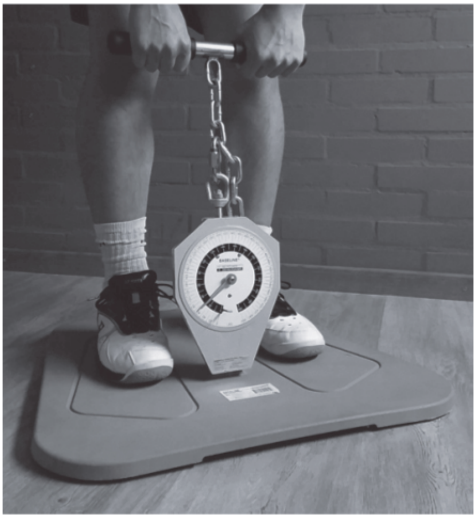

Figure 1. Back-leg-chest dynamometer

Isometric knee extensor and knee flexor strength For measuring isometric KES and KFS, the Biodex System 3 Pro dynamometer was used. Moments were recorded in Newton meters (Nm) with the Biodex Advantage Software for Windows. Participants were in a seated position, whereby the hip and knee joint were flexed at 80◦ and 90◦ respectively. The knee angle was measured by a goniometer to ensure the appropriate angle of the knee joint. The lateral femorale picondyle of the knee was lined-up with the axis of the lever arm of the Biodex dynamometer. To prevent compensatory movement, the upper leg and thorax were stabilized with straps. The lever arm was attached just proximal (ca. 3 cm) to the ankle joint. Familiarization trials of submaximal effort were performed for both isometric and isokinetic knee flexion and extension. After a short rest period of 30 seconds the actual test was performed, whereby the participants were asked to provide maximal voluntary isometric contractions for 5 seconds at 30◦, 50◦, 70◦, 90◦ and 99◦ of knee flexion and extension. Resting periods of 30 seconds were applied between each contraction to reduce fatigue and prevent muscular strain. Because the weight of the lower leg and the lever arm of the dynamometer caused passive knee moments, maximal moments had to be corrected for these passive moments. The passive moments were measured before the actual test, by asking the participant to relax the tested leg. Maximal knee flexion and extension strength was determined by fitting a cubic polynomial function to the five joint moment data. The y-top of the polynomial was considered the peak moment and was used for further analysis. The order of Biodex measurements (dominant and non-dominant leg) were balanced, whereby the dominant leg was determined by asking the individuals which leg would be preferred to kick a ball with.

Statistical analyses

IBM SPSS statistics 20 was used for data analysis. Independent samples T-tests were used to identify gender differences. Test-retest reproducibility of the BLC strength was tested using the Intraclass Correlation Coefficient (ICC) in order to determine the correlation and agreement between values. Bland-Altman plots were used to visualize the agreement between the two BLC strength-tests and examine the homo- or heteroscedastic nature of the distribution of the differences. The SRD was calculated using the formula: $2.77 \times SD \times \sqrt{(1\text{-}ICC)}$. When correlations between the difference score and mean score > 0.30, SRD%'s were calculated. The SRD% was calculated using the formula SRD% = SRD/M ×100%. An SRD% <30% was seen as acceptable level of measurement error (see also Chen et al., 2009). Pearson's correlations were used to identify associations of maximal HGS, isometric knee flexion and extension peak moments, and maximal back-leg-chest strength. A multiple regression model is used to determine whether HGS or KES and KFS predict back-leg-chest strength. In the regression procedure, the BLC strength-test of session 1 served as the dependent variable. In the first model, only gender was added as the independent variable. The second model analyzed the following strength variables: HGS of the dominant hand, HGS of the non-dominant hand, KES of the dominant leg, KES of the non-dominant leg, KFS of the dominant leg and KFS of the non-dominant leg. In the third model, gender and the aforementioned strength variables were combined. Stepwise regressions were used to determine the most important predictors.

Results

A total of 103 participants were examined, 45 adults, and 58 adolescents. Descriptive statistics for the main characteristics of the participants by age and gender are presented in Table 1. The female and male adults slightly differed by age ($p = 0.01$). Males were significantly taller, heavier, and stronger on all strength tests (all ps<0.001). In the adolescent population, no differences were found in age ($p = 0.86$) or weight ($p = 0.32$), but boys were signifcantly taller, and stronger on all strength tests (all p's<0.001).

Test retest reproducibility for the BLC dynamometer

The correlations between the measures of the BLC dynamometer-test in session 1 and session 2 were high for both female ($r = 0.92$) and male ($r = 0.93$) adults, and female ($r = 0.83$) and male ($r = 0.94$) adolescents. A high degree of reproducibility was found between BLC strength measurements, for male adults an ICC = 0.93 (95% CI: 0.90–0.98); for female adults, ICC=0.92 (95%CI: 0.88–0.98); for male adolescents, ICC = 0.83 (95% CI: 0.66–0.80); for female adolescents, ICC = 0.83 (95%CI: 0.52–0.95). The mean between-day variation for BLC strength was 2.67±12.36 kg in adults, and 1.21±15.85 kg in adolescents, with no differences in gender ($p = 0.05$ for adults, and $p = 0.64$ for adolescents). Bland-Altman plots show test-retest reproducibility of the BLC dynamometer in session 1 and session 2 using the error score (see Fig. 2). Correlations between the difference score (Y-axis of Blant-Altman plot) and mean score (X-axis of Blant-Altman plot) are $r = -0.36$ for adults, and $r = 0.28$ for adolescents. Therefore SRD%'s are calculated for adolescents, while those for adults should be viewed with reserve. The SRD% was calculated using the formula SRD% = SRD/M × 100%. An SRD% < 30% was seen as acceptable level of measurement error (see also [Chen et al., 2009, p.3]). SRD's and SRD%'s for male adults (26.2 and 19.9%), female adults (15.7 and 26.5%) and female adolescents (15.0 and 25.6% were all within the acceptable level of

Table 1. Study sample characteristics.

	Total Mean (*SD*)	Male Mean (*SD*)	Female Mean (*SD*)	*p*
		Adolescents		
N	58	30	28	
Age (year)	13.9 (1.1)	13.8 (1.2)	13.9 (1.0)	.84
Height (m)	168.0 (9.2)	171.9 (9.4)	163.9 (7.0)	.001
Weight (Kg)	54.5 (9.2)	55.7 (9.5)	53.2 (8.9)	.32
.BMI (kg/m^2)	19.2 (2.1)	18.7 (2.0)	19.8 (2.2)	.07
BLC-strength 1 (kg)	68.1 (24.3)	79.2 (27.1)	56.3 (13.4)	<.001
BLC-strength 2 (kg)	73.1 (27.1)	84.1 (34.4)	60.8 (13.7)	.001
HGS d (Kg)	34.1 (8.5)	37.8 (9.5)	30.0 (4.8)	<.001
HGS nd (Kg)	32.1 (7.6)	36.3 (7.8)	27.7 (4.2)	<.001
		Adults		
N	33	13	19	
Age (year)	24.7 (3.2)	26.0 (3.1)	23.9 (3.0)	.06
Height (m)	174.8 (8.9)	182.7 (6.3)	169.3 (5.7)	<.001
Weight (Kg)	70.4 (12.1)	80.9 (6.4)	63.5 (9.7)	<.001
BMI (kg/m^2)	23.1 (2.6)	24.3 (2.3)	22.3 (2.4)	.03
BLC-strength 1 (kg)	90.0 (53.6)	148.1 (35.2)	52.3 (15.7)	<.001
BLC-strength 2 (kg)	90.2 (45.5)	140.8 (25.9)	58.2 (15.7)	<.001
HGS d (Kg)	42.9 (14.1)	55.3 (12.4)	34.8 (8.0)	<.001
HGS nd (Kg)	39.6 (12.8)	50.8 (10.5)	32.4 (8.3)	<.001
KES d (Nm)	198.7 (76.1)	274.7 (58.8)	146.6 (25.6)	<.001
KFS d (Nm)	92.5 (34.5)	125.0 (30.2)	70.2 (12.5)	<.001
KES nd (Nm)	190.2 (74.8)	270.5 (57.4)	142.1 (26.7)	<.001
KFS nd (Nm)	91.2 (30.9)	122.5 (23.4)	72.4 (15.8)	<.001

measurement error. Only the SRD and SRD% for boys (34.2 and 42.2%) were not. However, when taking out the one boy that did not fit in the limits of agreement (as clear single outlier; see also Fig. 2), the SRD and SRD% decreased to an acceptable 17.6 and 22.1% respectively. In very general terms these scores indicate that an increase of at least 20% will be needed to evidence an improvement in BLC; for a healthy and strong subject this would constitute a major undertaking. On the other hand, it might be a more realistic cutoff in some clinical situations where this type of strength is low and therefore exceeding the 20% should be a reasonable objective.

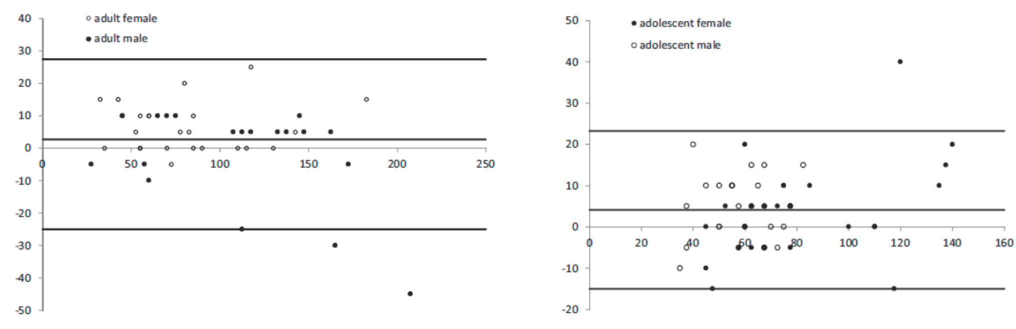

Figure 2. Blant-Altman plot's indicating the mean difference with limits of agreement between BLC-test 1 and BLC-test 2 in adolescents and adults.

Strength measure correlates

In adults (males and females separated), significant correlations were found between the BLC strength and HGS in males, but not in females. All KES and KFS were significantly related to BLC strength. No significant correlations between HGS and KES or KFS were found (all p's > 0.07; data not shown). In adolescents, BLC strength was significantly correlated with HGS in boys, but not in girls (see Table 2). At http://focusonstrength.net, a full correlation matrix can be found. Gender predicted 62% of BLC strength, whereas the strength variables explained a significant proportion of 87% of the variance. The complete model, with both gender and strength variables, explained variance by 88% (Table3). A stepwise linear regression shows that dominant KES and KFS were the most important significant predictors of BLC strength ($r^2 = 0.86$).

Table 2. Correlations of handgrip strength, leg extension strength, leg flexion strength, with back-leg-chest strength (session 1).

		Back-leg-chest strength		
			Adolescents	
		Total	Male	Female
Dominant hand	Handgrip	.72***	.71***	.38*
Non-dominant hand	Handgrip	.77***	.78***	.31
			Adults	
Dominant hand	Handgrip	.71***	.27	.13
Non-dominant hand	Handgrip	.75***	.45	.23
Dominant leg	Extension	.85***	.41	.43
	Flexion	.80***	.27	.64**
Non-dominant leg	Extension	.91***	.74**	.42
	Flexion	.84***	.39	.61**

Table 3. Multiple regression analyses predicting back-leg-chest strength from gender (model 1), handgrip strength, leg extension strength, and leg flexion strength (model 2), and a combination (model 3).

		Model 1 Standardized β	Model 2 Standardized β	Model 3 Standardized β
Gender		-.89	-	-.31
Dominant hand	Handgrip	-	-.28	-.37
Non-dominant hand	Handgrip	-	.45	.46
Dominant leg	Extension	-	.38	.26
	Flexion	-	.002	.03
Non-dominant leg	Extension	-	.35	.28
	Flexion	-	.12	.05
Adjusted R^2		**.78**	**.87**	**.88**

Discussion

A single measure to characterize overall muscle strength is advantageous because it saves time and costs of evaluation. In the past, Bethards and colleagues (1995) showed a high intra-rater reproducibility of BLC dynamometer measures in adults. Our study replicated the results found by Bethards, but then separately for male and female healthy adults. Additionally, we demonstrated that the BLC dynamometer provides reasonable reproducibility of BLC strength in healthy adolescents. Furthermore, the present study showed that in adult participants, HGS, KES and KFS effectively predict BLC strength measured with the BLC dynamometer. These findings advocate the use of the BLC dynamometer in examining overall limb muscle strength, at least in healthy adults. The results of the present study imply the applicability of the BLC dynamometer. Together with its simplicity and portability, this - up till now seldom-used – apparatus might be an appropriate tool in research lab, field research, and clinical settings. Currently, the usefulness of the BLC dynamometer has been described rarely (Coleman et al., 2011; Sadeghi et al., 2012; Sener et al., 2013). Coleman and colleagues (2011) used the BLC dynamometer in patients with Multiple Myeloma, and showed that fatigue, pain, sleep, mood and functional performance were interrelated. Sadeghi and colleagues (2012) concluded that the BLC dynamometer is not related to heart rate/work hardness. By using the BLC dynamometer, Sener and colleagues (2013) found that muscle strength is related to quality of life, depression, and anxiety symptomatology in patients with fibromyalgia. By using the SRD and SRD%, a rough relative smallest measurement change that can be interpreted as a real difference was calculated (Beckerman et al., 2001). Although the Blant-Altman plots showed some heteroscedasticy, the values found in this study are similar to findings in other studies looking at test-retest reproducibility of isometric strength tests, e.g., in hand function tests (Chen et al., 2009), and knee extension and flexion tests (Adsuar et al., 2011).

Other practical applications: Considerations for use

Several other factors, limitations and strengths have to be considered concerning the use of BLC dynamometer as a measure. First, the apparatus induces execution of static contractions, which are required less often in daily life compared to dynamic contractions. Moreover, rehabilitation and training programs often focus on dynamic training modes. While isometric training is suggested to be more effective than isokinetic training (Adsuar et al., 2011; Beckerman et al., 2001; Sener et al., 2013), this training mode is limited as it increases strength at a specific training angle, but with slight transference to other muscle lengths (Thepaut-Mathieu et al., 1988; Weir et al., 1995; Lindh, 1979). Since the BLC dynamometer measures muscle strength in one angle, it provides limited information about muscle function. However, the BLC dynamometer can be used in multiple ways, where different strengths can be measured by instructing different body positions. In this study, specific instructions were given to participants for using the BLC dynamometer. Future studies should examine the applicability of the BLC dynamometer for other muscle groups.

Second, some participants experienced the BLC dynamometer test as unpleasant, because of soreness of the lower back during the test that disappeared immediately or within several hours after the test. For this reason, clear instructions about the correct body position, emphasizing the maintenance of an appropriate lordotic curve of the lumbar spine, is essential. Moreover, in order to allay participants' concerns, it is important to provide information about possible sensational feelings during and after the test, and explain that these feelings are a normal response to unusual exertion and do not imply tissue damage. Third, we used two BLC dynamometers in one of our subsequent studies, measuring about 800 healthy adolescents aged 12–15 years in school setting. Both apparatus broke during the experiment (i.e., the pointer stopped moving). Although the apparatus was quickly and easily fixed, our impression is that the inner work (plastic toothed wheels) should be replaced by higher quality materials. Fourth, our study had a relatively small sample size and examination of the strength predictor variables KFS and KES was performed in adult participants only. Therefore, further research is necessary to examine whether these results can be generalized to other age groups. Finally, the difference between the first and second BLC dynamometer measures were within the limit of agreement (except for a few outliers), but sometimes still very large. In each study the pros (i.e., portability and testing larger muscle groups outside the lab setting) and cons (variability in measures) need to be considered carefully. For example, for a normal subject to increase the BLC strength reading by 20% might be a major task. On the other hand, it might serve in some clinical situations where this type of strength is low and therefore exceeding the 20% should be a reasonable objective.

Conclusion

In conclusion, the BLC dynamometer provides reasonably reliable test-retest measurements of BLC strength in healthy adolescents and adults and might therefore be considered an appropriate tool to evaluate changes in muscle strength in research and clinical settings. Additionally, HGS and KES are shown to be strong predictors of BLC strength in healthy adults, advocating the use of the BLC dynamometer in examining overall limb muscle strength.

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Chapter 7

The Dutch 'Focus on Strength' intervention study protocol:
program design and production, implementation and evaluation plan.

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Abstract

Background: Overweight youngsters are better in absolute strength exercises than their normal-weight counterparts; a physiological phenomenon with promising psychological impact. In this paper we describe the study protocol of the Dutch, school-based program ‘Focus on Strength’ that aims to improve body composition of 11–13 year old students, and with that to ultimately improve their quality of life.

Methods: The development of this intervention is based on the Intervention Mapping (IM) protocol, which starts from a needs assessment, uses theory and empirical research to develop a detailed intervention plan, and anticipates program implementation and evaluation. This novel intervention targets first year students in preparatory secondary vocational education (11–13 years of age). Teachers are the program implementers. One part of the intervention involves a 30 % increase of strength exercises in the physical education lessons. The other part is based on Motivational Interviewing, promoting autonomous motivation of students to become more physically active outside school. Performance and change objectives are described for both teachers and students. The effectiveness of the intervention will be tested in a Randomized Controlled Trial in 9 Dutch high schools.

Discussion: Intervention Mapping is a useful framework for program planning a school-based program to improve body composition and motivation to exercise in 11–13 year old adolescents by a “Focus on Strength”.

Trial registration: NTR5676, registered 8 February 2016 (retrospectively registered).

Background

Obesity is a growing health problem globally (NCD Risk Factor Collaboration, 2016; Swinburn et al., 2011). It is an established risk factor for chronic metabolic and cardiovascular diseases (Kelsey et al., 2014; Washington, 2008). In overweight and obese children and adolescents, not only metabolic health, but also psychological wellbeing is at risk (Gately et al., 2000; Kelsey et al., 2014; Van der Baan et al., 2010). Besides overeating and genetic susceptibility, an insufficient level of physical activity is one of the main contributors to childhood overweight and obesity (Kremers et al., 2005), and the target of many obesity reduction programs (Lee et al., 2012). However, most of these interventions are not successful (see e.g., meta-analyses by Guerra et al., 2013, 2014; Harris, et al., 2009; Metcalf et al., 2013).

In this paper we describe the study protocol of the new, Dutch, school-based ‘Focus on Strength’ intervention. Recent evidence indicates plausible effects of the role of strength exercises in combating the negative health effects of childhood obesity (see e.g., Lloyd et al., 2014; summarized in **Chapter 1 and 2**). Overweight youngsters do not only have a higher fat mass, but also a higher fat-free (muscle) mass compared with their normal-weight counterparts (Westerterp et al., 1995a; **see also Chapter 4**). With that, they are also stronger and better in exercises wherein the focus is on absolute strength, making them – under the right circumstances – more motivated to engage in strength exercise and ultimately maintain a physically active lifestyle. In the past, it has been suggested that strength exercises are harmful for youngsters, particularly during growth (i.e., growth plate injuries or stunted growth). However, more recent data indicate that this is a persistent misperception devoid of any evidence (Barbieri et al., 2013; Benjamin & Glow, 2003; Benson et al., 2008; Faigenbaum, 2007; 2010; Lloyd et al., 2014). As long as strength exercises are performed under qualified supervision, they can even prevent injuries and cause a rapid rehabilitation from injuries (Lloyd et al., 2014; Sothern et al., 2000). Lately, the short-term and long-term benefits of youth resistance exercises have become more and more evident (for an elaborate overview, see Lloyd et al., 2014). Although resistance exercises do not reduce weight or BMI per se (Kelley & Kelley, 2013), they can induce a shift in body composition by increasing one’s fat-free mass (Cloutier et al., 2014; Schranz et al., 2013), strength, motor skills, and energy balance on the long term (Lloyd et al., 2014; Paoli et al., 2015; Vasquez et al., 2014).

In the Focus on Strength program, we do not focus on what youngsters have to do, but we try to (intrinsically) motivate youngsters to engage in physical activity health behavior that they like to do, thus promoting behavior change maintenance (**see Chapter 1 and 2)**. We aim to minimize obesity stigma by focusing on the general 11–13 year old high school population, and not only on overweight or obese youngsters. Also, we do not aim to focus on weight loss, or weight adjusted for height (BMI) improvements, but on improvements in body composition. Compared to body mass or BMI, body composition (ratio fat-free mass: fat mass) is a better predictor of health, also for young people (Dixon, 2010).

The development of the Dutch, school-based ‘Focus on Strength’ intervention is based on the Intervention Mapping (IM) protocol (Bartholomew et al., 2016; Kok et al., 2015). IM describes the iterative path from problem identification to problem solving or mitigation. The six steps of IM comprise several tasks each of which integrates theory and evidence. The completion of the tasks within a step creates a product that guides the subsequent step. The completion of all of the steps serves as a blueprint for designing, implementing and evaluating an intervention based on theoretical, empirical and practical information. The six steps of the IM process are displayed in Figure 1.

The key words in IM are planning, research, and theory. IM provides a vocabulary for program planning, procedures for planning activities, and technical assistance with identifying theory-based determinants, and matching them with appropriate methods for change at different ecological levels including target group, stakeholders, environmental agents, and program implementers.

Step 1. Logic model of the problem. Conduct a needs assessment or problem analysis by identifying programme objectives: what, if anything, needs to be changed and for whom.

Step 2. Program outcomes and objectives – Logic model of change. Create matrices of change objectives by combining (sub-)behaviours with behavioural determinants to identify which beliefs should be targeted by the intervention.

Step 3. Program design. Select theory-based intervention methods that match the determinants into which the identified beliefs aggregate, and translate these into practical applications that satisfy the parameters for effectiveness of the selected methods.

Step 4. Program production. Integrate the practical applications into an organized programme.

Step 5. Program implementation plan. Plan for adoption, implementation and sustainability of the programme in real-life contexts by identifying programme users and supporters and determining what their needs are and how these should be fulfilled.

Step 6. Evaluation plan. Generate an evaluation plan to conduct effect and process evaluations to measure programme effectiveness.

Figure 1 Intervention Mapping steps

Methods and results

This intervention focuses on first year students in preparatory secondary vocational education (11–13 years of age) as target population, and their teachers as implementers. Therefore, in this school-based approach, there is both a students' program and a teachers' program. For step 1 to 4 of the IM protocol, the two pathways are described in parallel.

A school-based approach may induce stigmatization in particular when an intervention only would include a focus on overweight and obese youngsters. Therefore, in accordance with the merits of social comparison theory (Lemaine, 1974; Suls et al., 2013; Van Knippenberg et al., 1981), we chose to develop a program in which overweight and normal-weight youngsters exercise together. Because our program includes the general 11–13 year old high school population, and not only on overweight and obese youngsters, we strongly reduce the risk of stigmatization (Puhl & Heuer, 2010). Although the entire program development focuses on all youngsters, it is expected to be more beneficial for overweight and obese youngsters in terms of program outcomes. Given that overweight youngsters are better in strength exercises than normal weight youngsters, overweight youngsters may find out that they perform better in the domain of strength exercises (contrary to the domain of aerobic exercises), which, in time, is hypothesized to improve their feelings of competence and relatedness and their self-worth (Suls & Wheeler, 2002).

Some authors have suggested that stimulating social comparison may have detrimental effects on autonomous motivation (Ames & Archer, 1988) while others suggest that social comparison is part of typical classroom settings and that perceptions of competence and relatedness are predictive of autonomous motivation (**see Chapter 2**). Positive social experiences with strength exercises may, in time, increase intrinsic motivation for exercise in overweight youngsters. Moreover, having youngsters compete as teams in multi-component exercises, combining aerobic and strength tasks, might encourage interpersonal appreciation of various skills, e.g., speed vs strength.

Step 1 and Step 2: Needs assessment and program objectives

In the first step of IM, the health problem, the related behavior and the associated determinants for the at-risk population need to be clarified. In this needs assessment, a description of a specific health problem, its impact on quality of life and behavioral and environmental causes and determinants are formulated (as indicated in the Background). In the second IM step, behavioral, performance and change objectives are formulated. Here, the foundation for the intervention will be provided by specifying who and what will change when the intervention will be executed.

Program objectives

The overall objective of this intervention is to improve body composition of 11–13 year old students, and with that to ultimately improve their quality of life. Participation of all stakeholders is guaranteed through regular meetings with the school management and teachers, and a survey among students. The most important implementers are the teachers. To improve body composition, the health promoting behavioral program objective for the physical education (PE) teachers is to promote strength exercises in their students. This requires a sharper focus on strength exercises in physical education lessons, resulting in the students spending at least 30 % of the PE lessons on strength exercises (an average of approximately 15 min per lesson). The choice for 30 % was the outcome of meetings with PE teachers about the feasibility of integrating strength exercises in the standard curriculum. The behavioral program objective for the students is that they, in addition to the PE lessons, become more physically active outside school (i.e., at least 1 h/day of physical activity per day, and preferably more, according to internationally accepted recommendations) (See Fig. 2).

Performance objectives for teachers and students

Performance objectives are the description of the specific preparatory and sub-behaviors that the students and teachers have to perform to achieve the desired change. For adding more strength exercises in PE classes, the performance objectives that were chosen in collaboration with the PE teachers are: plan, prepare and adapt strength exercises for their lessons; locate appropriate (safe) equipment, and if not or not sufficiently available, get (extra) support from the school’s management; adapt and continue strength exercises through the school year (see Table 1).

To improve their level of physical activity, students have to go through a process of self-regulation related to many aspects of physical activity (Mann et al., 2013). They first have to monitor their current physical activity situation, relate that to physical activity norms, and decide to increase own physical activities. Then, the students make action plans, experience different kinds of physical activities, and discover what kind of physical activity they like. Then they identify and eliminate possible barriers. Finally, students have to continue their physical activity behavior over time (see Table 2).

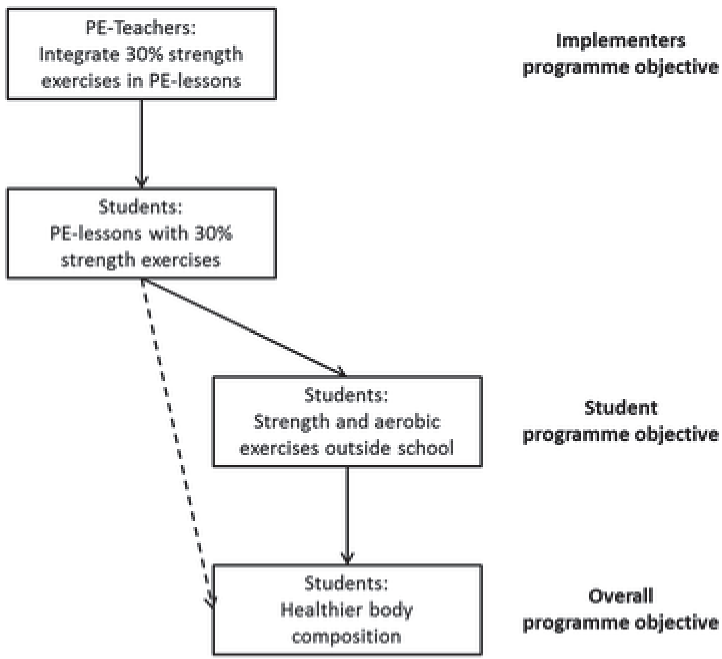

Figure 2 Program objectives

Table 1 Matrix of change objectives for the PE teacher

Program objective: 30 % more strength exercises in PE class. Performance objectives

	Determinants Knowledge	Skills & Self-Efficacy	Attitude	Perceived norms
PO1. Plan strength exercises in PE classes	K1.1. State the advantages (biologically and psychologically) of strength exercises in obese youngsters. K1.2. State that body composition improvements are more important than weight loss. K1.3. State that strength exercises improve body composition. K1.4. State that strength exercises are good for all students.	SSE1.1. Demonstrate the ability to add strength exercises to the PE classes. SSE1.2. Express confidence to add 30 % more strength exercises to all gym classes.	A1.1 Express that adding strength exercises has many more advantages than disadvantages. A1.2. Belief that the school is co-responsible for student's health, and that strength exercises contribute.	PN1.1. Explain that other PE teachers also plan strength exercises in PE classes.
PO2. Prepare strength exercises, (and use the workbook for inspiration).	K.2.1. List a sufficient number of strength exercises that can be used throughout the year, and which are appropriate for 11–13 year old students K2.2. State what is needed to maintain safety.	SSE2.1. Prepare lessons for PE classes SSE2.2. Express confidence that they can create strength exercises that can be used throughout the year, and which are appropriate for 11–13 year old students	A2.1. Belief that it's important to plan strength exercises ahead over the year.	
PO3. Adapt strength exercises based on experience.	K3.1. Indicate the differences among students (e.g., gender and physical development).	SSE3.1. Express confidence that they can give strength exercises appropriate for 11–13 year old students.	A3.1. State that well-adjusted, tailored strength exercises are advantageous for the students.	PN2.1. Recognize strength exercises as important aspects of PE class.
PO4. Locate appropriate (safe) equipment	K4.1. Explain what available equipment at the school is appropriate and safe for strength exercises.		A4.1. State importance of having sufficient, appropriate and safe equipment.	
PO5. Acquire additional materials through school management.	K5.1. Explain what new materials are needed		A5.1. Belief that the school is co-responsible for student's health, and that strength exercises contribute. A5.2. Belief that strength exercises can be positively discussed with the principle.	PN5.1 Talk about other school managements that acquire additional materials for strength exercises.
PO6. Adapt and Continue the strength exercises through the school year.	K6.1. List possible alternatives for strength exercises that might be more appropriate.	SSE6.1. Feel confident to deal with possible barriers.	P6.1. Belief that long term benefits can be achieved by continuation of the strength exercises throughout the school year.	

Table 2 Matrix of change objectives for the student

Program objective: Be physically active for at least 1 h/day after school

Performance objectives	**Determinants** **Knowledge**	**Skills & Self-Efficacy**	**Attitude**	**Perceived Norms**
PO1. Monitor own physical activity behavior. **PO2. Evaluate own physical activity behavior.**	K1.1 Rate own physical activity (1–10), K2.1 Explain why physical activity was not rated 2 points lower.(followup on K1.1)			PN1.1 Recognize that peers are physically active after school PN2.1. Talk to peers about their physical activity behavior.
PO3. Decide to increase own physical activity	K3.1 State 2 reasons why one should be physically active K3.2. Formulate physical activity goals	SSE1. Write down weekly physical activities	A3.1.Lists advantages of physical activity and disadvantages of physical inactivity.	PN1. State that 1 h/day physical activity is the generally accepted norm.
PO4. Make action plans to be physically active	K4.1.1. Lists places where one can be physically active	Expresses own physical activity qualities	Express positive attitudes toward action plans to be physically active	
PO4.1 Choose sports or physical activity	K4.1. List own positive qualities for physical activity.	SSE4.1.1. Recognize that different athletes have different qualities.	A4.1.1. Value own qualities as good/positive. A4.1.2. Express enjoyment in exercise of choice	PN4.1.1. Recognize that peers value their skills.
PO4.2 Get support from parents and peers.	K4.2.1 Name friends who want to join in physical activity K4.2.2. Explain how parents and peers can help to be physically active.			
PO4.3 Identify and eliminate barriers to start. **PO5. Identify and eliminate barriers for continuation of physical activity.** **PO6. Recycle to monitoring.**	K4.3.1. Identify and eliminate barriers to start. PO5.1 Describe possible barriers and solutions for continuation of physical activity			PN4.1. Recognize how peers deal with barriers to start PN5.1. Recognize how peers deal with barriers for commencement and continuation

Change objectives for teachers and students

Change objectives describe what needs to change, related to the determinants, for the person to execute the performance objectives. Change objectives combine determinants and performance objectives and are the basis for choosing theory- and evidence-based change methods and other program content. To change the behavior with the performance objectives in mind, the most important and changeable determinants of the behavior should be taken into account. In this program, these determinants are based on theory (Theory of Planned Behavior/Reasoned Action Approach; Fishbein & Ajzen, 2010; Self Determination Theory, Deci & Ryan, 2000; Social Comparison Theory, Van Knippenberg et al., 1981) and on meetings with teachers as well as (unpublished) survey data from students. In Tables 1 and 2 the change objectives for students and PE teachers are presented.

For PE teachers, the current situation in many high schools is that they have little support for the execution of strength exercises. From interviews with PE teachers, the most important change objectives derived were that they are aware of the positive influences of strength exercises, that they have a positive over-all attitude about strength exercises, and that they have a high perceived support from their environment, i.e., the school management, and other PE teachers. Furthermore, it is important that they have high self-efficacy and perceived skills to create the possibilities to execute strength exercises in their lessons.

Change objectives for the students are that they know the advantages and disadvantages of physical activity and inactivity, and understand that different physical activities require different qualities (e.g., a 100 kg judoka is not a good 100 m distance runner and vice versa). They develop a more positive attitude (e.g., fun), perceived norm and self-efficacy towards their own physical activity behavior outside school. Finally, students report a higher intention, are more aware of the possibilities for exercising outside school, and more autonomously motivated to engage in physical exercise.

Step 3 and Step 4: Program plan and design

To achieve the overall program objective of a healthier body composition in students, the PE teachers are the intermediates that implement the strength program. However, the implementation of strength exercises in PE lessons is not sufficient to achieve the program objective for the students to enhance their out of school PA level. To help the students through the process of self-regulation related to physical activity, a motivational program was developed for this study. This motivational program was based on Motivational Interviewing (Miller & Rollnick, 2013; Naar-King & Suarez, 2011). Motivational Interviewing is:

> *“A collaborative, goal-oriented style of communication with particular attention to the language of change. It is designed to strengthen personal motivation for and commitment to a specific goal by eliciting and exploring the person’s own reasons for change within an atmosphere of acceptance and compassion”* (Miller & Rollnick, 2013, pp. 29).

In Fig. 3 the overall design of the intervention is presented. The PE teachers integrate strength exercises in their PE lessons; overweight and obese children experience higher levels of competence and relatedness; students learn that strength exercises can be fun; a motivational intervention including autonomy support intends to enhance feelings of autonomy. Consequently, this combination of adjusted PE lessons and a motivational intervention would result in the enhanced feelings of autonomy, competence an relatedness that are required to increase the autonomous motivation for PA that helps students to continue engaging in out of school sports activities.

The methods used to prepare the PE teachers for the intervention are facilitation and participatory problem solving (see Bartholomew et al., 2016, pp. 378 and 391). The teachers are instructed about the program, participate in workshops to improve their motivational speaking skills, and are provided with materials to make them able to include strength exercises in their lessons. Furthermore, teachers receive a book with strength exercises and games as inspirational material. This inspirational material is based on literature, ideas from experts in the field, and from the PE teachers themselves (see Fig. 4 for an example, and http://focusonstrength.net for the complete Dutch book).

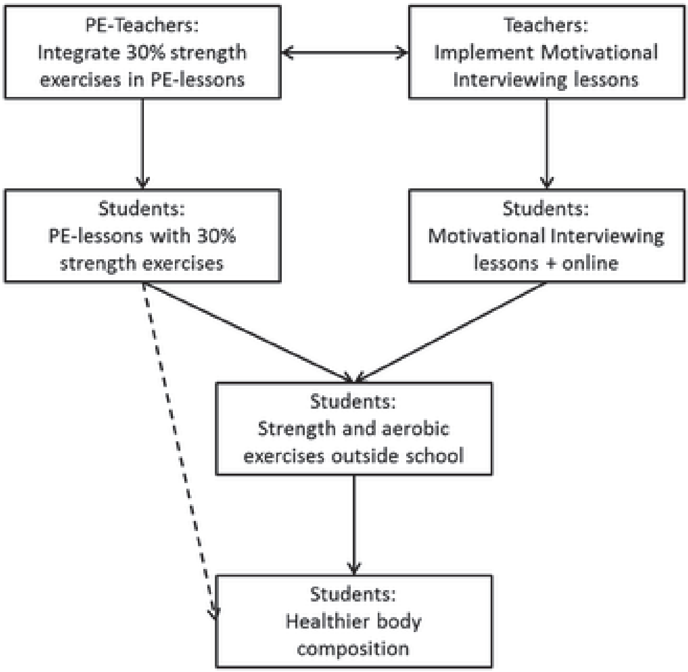

Figure 3. Overall design of the focus on strength program

To motivate students to be more physically active after school, and to improve the determinants of their physical activity behavior, the basic principles of Motivational Interviewing are applied. All students receive a workbook and once a month lessons to increase their motivation to be physically active outside school. The motivational intervention challenges students to make their own decisions and choices, herewith appealing to their feeling of autonomy. Together with the feelings of competence and relatedness the students experience during the PE lessons, the complete program, therefore, aims at improving all three of the basic psychological needs required for autonomous motivation (Ryan & Deci, 2002). The motivational lessons are facilitated by a trained mentor or PE teacher. In the first 5 months, a monthly extra online motivational lesson is given, in which students are provided with the opportunity to establish a shielded personal environment in which they do not feel judged by their fellow classmates. See Table 3 and http://focusonstrength.net for the content of each motivational lesson.

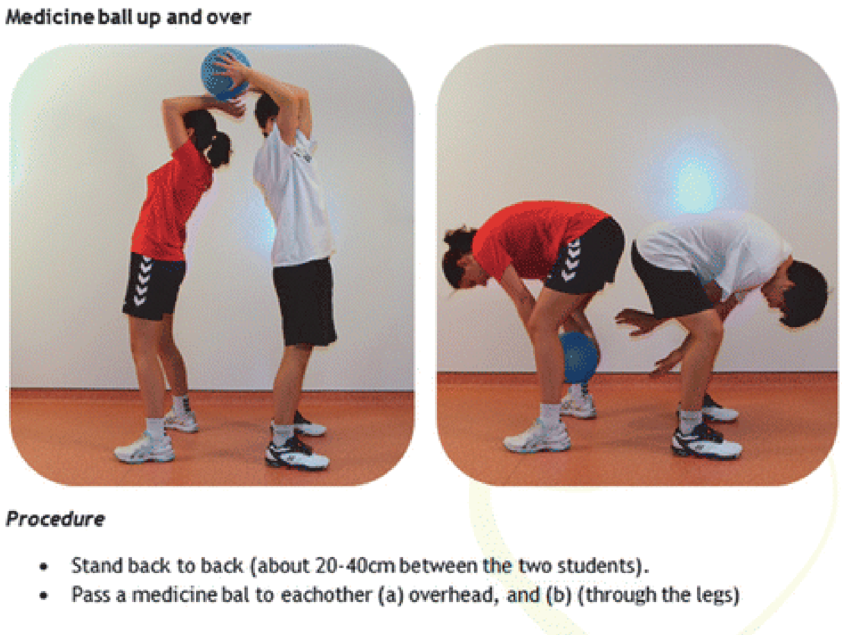

Figure 4 Example of the teacher’s book with strength exercises

Step 5: Implementation plan

In IM step 5 program developers set objectives for program adoption, implementation and maintenance and link these objectives to theoretical methods and practical applications for promoting adoption and implementation. In other words: who will do what, and how will this be facilitated.

The school management is an important stakeholder for this intervention. Commitment from the school management is essential to optimize communication with parents and within the school, and with that to optimise the support from the teachers. Moreover, involvement of the school management is important in order to make this program part of the regular curriculum of the school. Therefore, regular meetings with school managements guaranteed proper participation from the schools and improvement the study.

PE teachers organize and prepare strength exercises for their lessons using the workbook, locate and use appropriate (safe) equipment, and if not or not sufficiently available, get (extra) support from the schools management. Finally, they adapt and continue strength exercises throughout the school year, implementing the program with high completeness and fidelity. Project team members visit the schools regularly to provide assistance in case of difficulties, keep the PE teachers motivated and confirm support from the school management.

The performance objectives for the teachers who implement the motivational intervention are: organize, prepare and implement the motivational lessons. To promote implementation with high completeness and fidelity, these teachers participate in one or two training sessions, given by an expert Motivational Interviewing trainer. They are further supported with a written manual, they can ask for help and, again, project team members visit the schools regularly to provide assistance in case of difficulties, reinforce motivation and assure support from the school management.

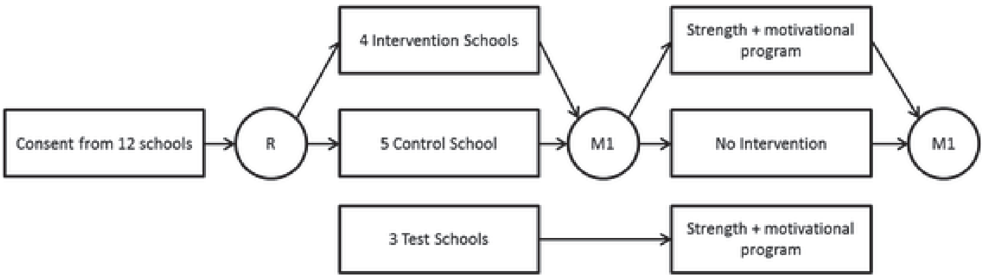

Figure 5 Study design

Step 6: Evaluation plan

Procedure In 12 high schools, all first grade students of preparatory secondary vocational education participate in a Randomized Controlled Trial (RCT). Schools are recruited via meetings with school managements. Three schools are used for pilot testing the program and its components. The other 9 schools are randomized in an intervention group (4 schools) and a control group (5 schools). In this 12 month RCT, it is the objective that at least 15–30 min of all physical education lessons in the intervention schools contain strength exercises (see also Fig. 5). This intervention, study methods and consent procedure were approved by the Ethical Review Committee of the Faculty of Psychology and Neuroscience, Maastricht University, the Netherlands [ERCPN, dd. 06-09-2015: ECP-04-09-2012; ECP-05-09-2012; ERCPN-04-09-2012A; ERCPN-05-09-2012A1].

Table 3 Content per motivational lesson

Lesson	Class/ Online	Topic	Motivational interviewing
1	C	- Own physical activity behavior - (anonymous) comparison to group norms	In this lesson, students become aware of their own physical activity behavior. Based on the anonymous physical activity group mean, students can compare and evaluate their own physical activity behavior
2	O	- Perceived level of own physical activity - Prepare lesson 3.	Students are asked to give a grade to their own physical activity behavior (1–10). After this, they are asked why they did not score 2 points lower. The idea here is that students come up with things they *are* doing.
3	C	- Advantages and disadvantages of physical activity and inactivity	The students discuss all advantages and disadvantages of physical activity and inactivity to create ambivalence.
4	O	- Physical activity and sedentary norms - Prepare lesson 4.	Students are made aware of the current physical activity norms (at 60 min of physical activity per day) and sedentary guidelines (less than 2 h of sedentary behavior per day).
5	C	- Awareness of different qualities of different athletes.	Different athletes are compared by means of Youtube videos. During this lesson, students are made aware that different physical activities require different qualities (e.g., a 100 kg judoka is not a good 100 m distance runner and vice versa).
6	O	- What physical activity suits me?	See also http://focusonstrength.net. this is a table/exercise adapted from the book 'Bewegen, Sport en Maatschappij' (physical activity, sports and society) by Boon, Pecht, Rijper & Stegeman (2008).
7	C	- Action planning	First the students are asked how confident they are to start or commence a physical activity. In the action plan the student describes the what, when, where, and how (what can they do themselves, who do they need, where can they find help) of their physical activity plan.
8	O	- Synthesis of lesson 1-7	Students write a short essay about what they want to do, what they want to achieve, and why.
9	C	- Commitment to the action plan	Students discuss how they will try to achieve their goals, and help each other when necessary.
10	O	- Improvement of action plan	
11	C	*Catch up month*	
12	C	- Own physical activity behavior - (anonymous) comparison to group norms - Action	Repetition of lesson 1. In this lesson, the students also have to come up with an idea of what physical activity behavior they want to start in the coming 2 months.
13	C	*Catch up monthn* *Action month*	Students are reminded of lesson 12 and their action plan
14	C	- Experiences and actions	Students discuss (perceived) barriers and solutions to overcome these barriers.
15	C	- Implementation intentions	If-then statements are made to help students to overcome (perceived) barriers.

After consent from the schools, the parents and their children are informed about the intervention and its measures. At all times, both parents and students are allowed to refuse participation in the measures. After the measures, all students in the intervention group participate in the PE lessons and motivational group lessons as this becomes part of the curriculum. The control group continues with their usual curriculum, without extra emphasis on strength exercises in their PE classes or on physical activity motivation. No motivational lessons are given in the control group. After 12 months, participating students will be included in a post measurement, using the same measurement procedure.

Measures

Gender and date of birth

Gender and date of birth are provided by the schools' students administration.

Anthropometrics

Anthropometrics are measured using standard procedures (National Health and Nutrition Examination Survey, III, 1988–94. National Center for Health Statistics, 1997). Both height (using the SECA 213 stadiometer) and weight (using the SECA 877 scale) are measured without shoes or heavy clothes to the nearest 1 mm and 0.1 kg respectively. Body Mass Index (BMI) is calculated as weight/height squared (kg/m2) and Z-scores from age- and sex specific reference values. The right arm, right wrist, waist and hip circumferences are recorded to the nearest 0.1 cm using a measuring tape.

Body composition

Two methods are used for measuring fat mass and fat-free mass. For the first method, total body water is measured with Deuterium Dilution using a slightly modified Maastricht Protocol (Westerterp et al., 1995b). After a baseline urine sample, the students drink 75 mL deuterium enriched water, increasing the deuterium body concentration with 100–150 parts per million. At the end of the school day (a minimum of 4.5 h later), a second urine sample is collected. To calculate total body water, the two urine samples (baseline and enriched) are analysed using isotope ratio mass spectrometry. From total body water, fat-free mass is calculated using age-specific hydration fractions of fat-free mass (Lohman, 1989).

For the second measure, skinfold measurements are taken to the nearest 0.1 mm. The thickness of skin folds is measured at four different sites, over the m. biceps brachii, the m. triceps brachii, sub-scapular, and supra-iliacal. From the sum of the four folds, body composition is estimated.

Muscle strength

A calibrated and validated (see **Chapter 6)** *back leg chest (BLC) dynamometer*; Baseline, New York, USA) measures isometric muscle strength, recorded in kilograms (kg) of force. When an external force is applied to a handle, which is attached to an adjustable chain, a steel spring compresses and a pointer moves. For the test, the length of the chain is adjusted to the participants' height by asking the subject to stand on the base of the BLC dynamometer with extended knees. Subsequently, the handle is positioned at the height of the intra-articular space of the knee joint. For the test, participants have to stand on the base, with flexed knees (ca. 30°) and hips while the lower back has to maintain an appropriate lordotic curve. Subjects are asked to lift with a continuous vertical motion by extending the knees, hips, and lower back while holding the handle. After demonstration and a familiarization trial, three trials of which each trial last for circa 3 s is performed, with rest periods of 30 s between trials. Maximal strength attained over the three trials is used for further analysis.

Dominant and non-dominant handgrip strength (HGS) is measured using the Jamar hydraulic hand dynamometer (Fess, 1987). Isometric HGS is measured according to the American Society of Hand Therapists. In short, the participants sit in a chair without arm rests. The shoulder remains at 0° flexion, abduction and rotation, the elbow is flexed at 90° and wrist is positioned between 0° and 30° dorsiflexion and between 0° and 15° of ulnar deviation. First, a demonstration and a familiarization trial are given for each arm. Then, the participants are instructed to continuously squeeze for 3–5 s for three trials, with a 30 s rest period between trials. The maximum value of the three trials is used for further analysis. Testing order (dominant/non-dominant) is balanced. The dominant hand is determined by asking the participants with which hand they write.

Aerobic capacity

To measure aerobic capacity, all students perform the shuttle run test (Leger et al., 1988). Students run back and forth over a distance of 18 m (officially the distance for a shuttle run test is 20 m, but because not all schools have a 20 m gym court, this test is taken over 18 m – therefore, comparisons within this study are valid, but the results cannot be compared with other studies). The running speed is determined by the interval between two sound signals (‘beeps’). Every minute, the speed increases by shortening the interval between two beeps. When a student fails to reach the 18 m-line at the sound signal two times in a row, the test stops for this individual.

Physical activity behavior

Physical activity in daily life is measured by accelerometer (see e.g., Trost et al., 2006). The Actigraph GT3x (Actigraph, Pensacola, FL, USA) triaxial accelerometer is a small device and measures acceleration in three directions (vertical, antero-posterior, and mediolateral). The first grade students were asked to wear the device for five consecutive days, except during sleep and water activities (e.g., taking a shower or swimming). The device is worn on their lower back by using an elastic band. The accelerometer provides activity counts as a composite vector magnitude of the combined three axes as well as time spent in sedentary, light, moderate and vigorous intensity physical activity.

Social cognitive determinants

The questionnaire measuring social cognitive determinants consists of three parts. In Table 4 the theory-based concepts are presented with example questions and answering categories. The first part of the questionnaire measures concepts of self-determination theory (Deci & Ryan, 2000). Enjoyment is measured with the Physical Activity Enjoyment Scale (PACES), adapted for children (Kendzierski & DeCarlo, 1991; Moore et al., 2009). The self-determination concepts are measured with the BrePAC (Bogaards, submitted), an adaptation for children of the Behavioral Regulation in Exercise Questionnaire (BREQ; Markland & Tobin, 2004) and the Sport Motivation Scale (SMS; Pelletier et al., 1995). Concepts measured are: enjoyment, intrinsic motivation, identified regulation, introjected regulation, regulation avoidance, and external regulation. Items are rated on a 4-point agree/disagree scale plus a ‘don’t know’-option.

The second part of the questionnaire measures concepts of social comparison theory (Suls & Wheeler, 2013), especially related to social comparison on two dimensions (Lemaine, 1974; Van Knippenberg et al., 1981; **Chapter 2)**. The two dimensions for all concepts are strength versus aerobic exercises. Concepts measured are: own performance (good/bad, pleasant/unpleasant, important/unimportant), social comparison (with someone better/worse than me), relative performance (better/worse than most other students, than students with higher weight, than students with lower weight), preference (very much/not at all for strength and aerobic exercises and a combination), choice of partner in an imaginary team performance (someone good in strength/in aerobic/both, someone with more weight/less weight/same weight), see Table 4. Items are rated on 7-point scales or multiple choice answers.

The third part of the questionnaire measures concepts from the Reasoned Action Approach (the successor of the Theory of Planned Behavior; Fishbein & Ajzen 2010) and Social Cognitive Theory (Bandura, 1986; Kelder et al., 2015). The focus in all questions is on doing sports, aerobic exercises, and strength exercises. Concepts measured are attitude (pleasant/unpleasant, important/unimportant, healthy/unhealthy, interesting/boring), injunctive social norm (friends, parents, people who are important to me), descriptive social norm (friends, most students my age), perceived behavioral control and self-efficacy (confident that I can, is under my control, confident even when my parents/friends do not support me), intention (plan to, expect to, will), see Table 4. All items are rated on 7-point scales.

Process evaluation Several steps will be taken to evaluate the implementation process of the intervention. First PE classes are observed on a regular basis to see how the PE teachers implement the strength exercises in their classes. Evaluation questionnaires are used to monitor activities of the PE teachers, the teachers that execute the motivational lessons, and the students. Using an online tool, the progress for the online lessons can be monitored.

Power calculation and statistical analyses Sample size calculations were performed based on the body composition (ratio fat-free mass/fat mass) improvements after 12 months for the intervention schools compared to the control schools. With $\alpha = 0.05$, power = 0.90, and a small to medium effect size ($d = .35$), 214 participants per group were needed. To test the effectiveness of the intervention, multilevel analyses will be conducted with SPSS. Three levels (student, class, and school) are identified to adjust for clustering of observations within a class or school. Taking the clustering in to account, that we randomized per school, and a drop-out rate of 10-15 %, we aim for a sample size of 600–700 participants.

Discussion

Intervention Mapping proved to be a useful framework for program planning this school-based program to improve body composition and motivation to exercise in 11–13 year old students by a “Focus on Strength”. Based on a combination of physiological and psychological insights, teachers will integrate strength exercises in their PE lessons and will provide motivational lessons. It is hypothesized that overweight students will find out they are better in strength exercises and all students will get more autonomously motivated to be more physically active outside school. The Intervention Mapping process helped planners to identify who and what should change and to select

Table 4 Questionnaire concepts and example items

Determinant	Items	Example question	Answers and rating
Self-determination: Behavioral Regulation of Physical Activity in Children (BRePAC and PACE)			
Enjoyment (PACES)	16	When I exercise, …I like doing it	Agree/disagree + [don't know] 5 point scale
intrinsic motivation	4	Why do you participate in exercises? …because it is part of me.	Agree/disagree + [don't know] 5 point scale
identified regulation	4	Why do you participate in exercises? …because I think it's important.	Agree/disagree + [don't know] 5 point scale
introjected regulation	5	Why do you participate in exercises? …to show others that I am good at it.	Agree/disagree + [don't know] 5 point scale
regulation avoidance (a-motivation)	4	Why do you participate in exercises? …so my teacher won't get angry with me.	Agree/disagree + [don't know] 5 point scale
external regulation	5	Why do you participate in exercises? …because others tell me to do that.	Agree/disagree + [don't know] 5 point scale
Social comparison concepts			
Performance	2	How good is your performance on strength exercises?	Very bad/Very good, 7-point scale
Social comparison	2	When doing aerobic exercises, I like to compare myself with some who is … than me.	Much worse/much better, 7 point scale
Relative performance	6	My performance on strength exercises is … than most other students.	Much worse/much better, 7 point scale
Preference	3	The next time I would … prefer to do a combination of aerobic & strength exercises.	Very strongly/not at all, 7 point scale
Partner choice	2	Imagine you compete with a partner against two other students. The game has a strength component and an aerobic component. Each of you choses one component. With whom would you prefer to form a team?	a. With someone good in aerobics and not in strength b. With someone good in strength and not in aerobics c. With someone good in both strength and aerobics
Reasoned action concepts			
Attitude	12	Me doing sports is…	Not at all pleasant/very pleasant, 7 point scale
Subjective norm	9	My parents expect me to do strength exercises.	Totally agree/totally disagree, 7 point scale
Descriptive norm	6	Many of my friends do aerobic exercises	Totally agree/totally disagree, 7 point scale
Self-Efficacy	12	If I wanted to, I am confident that I can do sports. Whether I do strength exercises is up to me. If I want to do aerobic exercises, I am confident that I can even when my parents don't support me.	Totally agree/totally disagree, 7 point scale
Intention	9	The next 3 months, I will do strength exercises regularly	Totally agree/totally disagree, 7 point scale

appropriate behavior change methods, practical applications and a feasible program that could be implemented by trained teachers.

In this paper we described the study protocol of the Dutch, school-based program 'Focus on Strength' that aims to improve body composition of 11–13 year old students through additional strength exercises, and with that to ultimately improve their quality of life. In this intervention, we focus on youngster's motivation, we aim to minimize obesity stigma, and we do not aim to focus on weight loss, but on improvements in body composition by encouraging strength training. To make overweight and obese youngsters healthier, stronger, happier, more confident (and feeling better in general), strength exercises may be a fruitful way to go in approaches to promote physical activity among children and adolescents.

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PART IV
AN EFFECTIVE PROGRAM?

Chapter 8

Strength exercises during physical education classes in high schools improve body composition: a cluster randomized controlled trial.

Ten Hoor GA, Rutten GM, Van Breukelen GJP, Kok G, Ruiter RAC, Meijer K, Kremers SPJ, Feron FJM, Crutzen R, Schols AMJW, Plasqui G. Strength exercises during physical education classes in high schools improve body composition: a cluster randomized controlled trial (Submitted for publication).

Abstract

Background: Metabolic health in people with obesity is determined by body composition. In this study, we examined the influence of a combined strength exercise and motivational program – embedded in the school curriculum– on adolescents' body composition and daily physical activity.

Methods: A total of 695 adolescents (11-15 years) from nine Dutch secondary schools participated in a one year cluster randomised controlled trial (RCT). In the intervention schools, physical education teachers were instructed to spend 15-30 minutes of all physical education lessons (2x/week) on strength exercises. Monthly motivational lessons were given to stimulate students to be more physically active. Control schools followed their usual curriculum. The primary outcome measure was body composition assessed by the deuterium dilution technique. Daily physical activity measured by accelerometry served as a secondary outcome.

Results: After 1 year, a 1.6% fat mass difference was found in favour of the intervention group (p=.007). This reflected a 0.9kg difference in fat free mass (intervention>control; p=.041) and 0.7kg difference in fat mass (intervention<control; p=.054). Daily physical activity decreased from baseline to posttest in both groups, but less so in the intervention group (p=.049). After 1 year, a difference of 0.4% was found for moderate to vigorous physical activities in favour of the intervention group (p=.046). No differences in sedentary behaviour, or light physical activity were found between groups.

Conclusion: In 11-15 year olds, the combination of strength exercises plus motivational lessons contributed to an improvement in body composition and a smaller decrease in physical activity level.

Introduction

Obesity, defined as an excessive body fat percentage, is a growing health problem globally and an important risk factor for chronic metabolic and cardiovascular diseases (NCD Risk Factor Collaboration, 2016; Swinburn et al., 2011). Nowadays, more and more children are obese, and without preventive measures, a child's unhealthy weight is likely to be sustained in later life (Kelsey et al., 2014; Washington, 2008).

Besides overeating and genetic susceptibility, an insufficient level of physical activity is one of the main contributors to childhood overweight and obesity (Kremers et al., 2005), and the target of many obesity reduction programs (Lee et al., 2012). These programmes often focus on 1) reduction of body weight and/or 2) improvements in the daily physical activity pattern. However, while quickly reducing weight may result in short term success, weight is often regained quickly as a result of several mechanisms (Ochner et al., 2013). More long-term, sustainable improvements in daily physical activity are often difficult to achieve for people with overweight or obesity: negative experiences may result in loss of motivation, causing the individual to further disengage from physical activity. This may contribute to an increase in weight, which in turn may result in even lower levels of physical activity, and thus the vicious cycle continues (see **Chapter 1 and 2)**. Attempts to increase physical activity in children or adolescents often focus on aerobic exercises. However, it is increasingly suggested that strength exercises should be incorporated into a child or adolescents' daily life (see **Chapter 1 and 2).** These exercises can improve body composition, i.e. an increase fat free mass and/or reduction in fat mass percentage. A higher fat free mass results in an increase in basal metabolic rate and total energy expenditure. In addition, a lower fat mass percentage improves several cardiovascular risk factors (Freedman et al., 2015). There may also be psychological advantages associated with strength exercises, particularly for overweight youngsters who are generally stronger and will outperform their normal-weight peers during strength tests, increasing compliance and enjoyment (see **Chapter 1 and 2)**, which can in turn contribute to higher participation in physical activity after school.

In this cluster RCT, we investigated the one-year efficacy of incorporating strength exercises into gym classes, in combination with monthly motivational lessons (to engage in physical activities after school) on the body composition and physical activity of adolescents.

Methods

Study design

Nine Dutch secondary schools (seven schools with Lower Vocational Education, two schools with Senior General Secondary Education) were randomised (stratified on education level; by flip of a coin by the first author) into an intervention condition (four schools) or a standard curriculum control condition (five schools). The intervention period was between March 2015 and March 2016. Measurements were taken before (T0) and directly after (T1) intervention. Trial registration ID: NTR5676 (http://www.trialregister.nl).

Study population

Schools were recruited via school management and 695 adolescents (11-15 years old) participated. Following consent from the schools, parents and their children were informed about the intervention and related outcome measurements, and told they could refuse participation at any time. The study methods and consent procedure were approved by the Ethical Review Committee of the Faculty of Psychology and Neuroscience, Maastricht University, the Netherlands [ERCPN-05-09-2012A1].

Study interventions

The intervention group received both a strength exercise intervention and a motivational intervention to promote after school physical activity, while the control group continued with their usual curriculum.

Strength intervention At least 30% of the physical education lessons in the intervention group focused on strength exercises (approximately 15-30 minutes per lesson), facilitated by the physical education teacher. This proportion was based on the feasibility of integrating strength exercises into the standard curriculum (see also an inspirational workbook on http://focusonstrength.net).

Motivational intervention Once a month, a one-hour lesson was used to increase motivation to be more physically active (see also **Chapter 7** or http://focusonstrength.net for an overview of these lessons, including the Dutch workbook). These motivational lessons were based on motivational interviewing (Rollnick et al., 2016) and facilitated by a trained mentor or PE teacher. In each of the first five months, an extra monthly online motivational lesson was given. Together with the feelings of competence and relatedness students experience during the physical education lessons, the complete programme, therefore, aimed to improve the three basic psychological needs required for autonomous motivation according to Self-Determination Theory (Ryan & Deci, 2002).

Study outcomes

Sex and date of birth were provided by the school's student administration. Anthropometrics were measured using standard procedures (15. National Health and Nutrition Examination Survey, 1997). Height (SECA 213 stadiometer, Hamburg, Germany) and weight (SECA 877 scale, Hamburg, Germany) were measured without shoes or heavy clothes (i.e. only pants and t-shirt) to the nearest 1 mm and 0.1 kg respectively. Body Mass Index (BMI) was calculated as weight/height squared (kg/m2) and Z-scores from age- and sex specific reference values (Fredriks et al., 2000).

Body composition was assessed by deuterium dilution (Westerterp et al., 1995). After a baseline urine sample, participants drank 75mL deuterium-enriched water, increasing the deuterium body concentration with 70-100 parts per million. At least four hours after drinking the deuterium enriched water, the students were required to visit the toilet at least once. This urine was not collected. At the end of the school day (a minimum of 4.5h later), a second urine sample was collected. To calculate total body water, the two urine samples (baseline and enriched) were analyzed using isotope ratio mass spectrometry (Schoeller et al., 1986). From total body water, fat-free mass was calculated using age-specific hydration fractions (Lohman, 1989).

Physical activity behaviour in daily life was measured using accelerometry (Actigraph GT3x, Actigraph, Pensacola, FL, USA). Students were asked to wear the device on their lower back for five consecutive days, except during sleep and water activities (e.g. taking a shower or swimming). The device was worn on their lower back by using an elastic band. The accelerometer provides activity counts (counts per minute; CPM); a higher CPM indicates more physical activity in daily life. Only students who had worn the accelerometer at least 8 hours per day for a minimum of 3 days were included in the analyses (see Table 2). Wear and non-wear times were determined by the algorithm of Choi and colleagues (2011) and physical activity level cut-off points were determined as proposed by Mattocks and colleagues (2007) The comprehensive intervention study protocol is described in **Chapter 7.**

Sample size and statistical analysis

Sample size calculations were performed based on body composition (fat mass percentage) improvements after 12 months for the intervention schools compared to the control schools. With $\alpha = 0.05$, power = 0.90, and an assumed small to medium effect size ($d = .35$), 172 participants per group would be needed for a classical RCT. However, in view of the clustering of students within schools and randomised assignment of schools (cluster randomised trial), we aimed for a sample size of 600 to adjust for the design effect arising from clustering (Van Breukelen & Candel, 2012). The sample size was further increased to 700 to accommodate 15% dropout (although all available data from all participants would be included into the analysis).

Statistical analyses were conducted with IBM SPSS Statistics 20. Outcome variables were body composition (fat mass percentage, absolute fat mass in kg, and absolute fat free mass in kg), weight, and physical activity (in counts per minute, percentage of time spent in sedentary behaviour, light physical activity, and moderate to vigorous physical activity). Mixed (multilevel) regression was used to identify baseline differences between the two conditions on each of the outcomes (with a random school effect on top of the individual pupil effect to adjust for the clustered nature of the data). To test the effectiveness of the intervention mixed regression was used for each outcome variable, using the pretest and posttest as repeated outcome measures, and using time (0=pretest, 1=posttest)), condition (0=control, 1= intervention), sex (0= female, 1 = male), age, BMI at baseline, and level of education (0= Lower Vocational Education, 1 = Senior General Secondary Education) as predictors, plus the interactions of condition, sex, age, BMI and education with time. The random (variance) model part consisted of an unstructured covariance matrix for the within-school variances and covariance of the two repeated measures plus a random intercept for the between-school outcome variance. All participants with at least one measurement (pre or post) were included into the analysis without imputing missing values. This so-called “direct likelihood” method is valid under the same assumptions about missingness as multiple imputation (Verbeke & Molenberghs, 2000). The initial mixed model additionally contained three-way interactions of time*condition*BMI baseline (and condition*BMI baseline), and time*condition*sex (and condition*sex).[a]

Using Maximum Likelihood estimation and likelihood ratio testing (Verbeke & Molenberghs, 2000). non-significant three-way interactions were removed from the model. Subsequently, non-significant two-way interactions were removed, apart from the condition by time

[a] Following baseline measurements, we found out that in one of the schools, 3 out of 5 classes that had been allocated to the intervention condition were going to be transferred (after five months) to another school that had been allocated to the control condition. To minimise the chance of contamination, these 3 classes did not receive the intervention. To check the effect of this protocol deviation on the outcome variables, an extra predictor was added to the model, which indicated this treatment switch (0= not switched, 1 = switched), and its interaction with time was added as well. Neither that interaction nor the main effect of switch after dropping the interaction from the model was significant for any outcome, probably due to low power resulting from the fact that outcome measurements were missing for most switchers anyway. The reported effect analyses therefore do not adjust for switch, thus complying with the intention to treat principle (for further details of missingness, see the Results section).

interaction of interest, and any two-way term that was part of a significant three-way term (e.g. age*time if the model still contained condition*age*time). Finally, non-significant ($p > .05$) main effects were deleted, except those that were part of an interaction term in the model (e.g. age if age*time was in the model). All tests were carried out using alpha = 0.05 two-tailed. The final model was rerun with restricted maximum likelihood estimation (REML) to obtain the best estimates of the standard errors of all effects (Verbeke & Molenberghs, 2000). The model was also rerun after deleting the condition term from the model, which reflects the baseline outcome difference between conditions and should not be significant due to the randomisation. The condition*time effect of interest in this model was compared to that obtained with the final model including the condition term as a robustness check (see van Breukelen, 2006; 2013).

For all outcome variables, intraclass correlations (ICC) were calculated (per time point) to assess the amount of outcome variance between schools, and normality checks were performed based on the final mixed model (see http://focusonstrength.net).

Non-identifiable data, syntax and output of the analyses are fully disclosed (see http://focusonstrength.net).

Results

Study population

Participant characteristics at baseline are shown in Table 1. No baseline differences were found between the two conditions in age, height, weight, BMI(z), body composition or physical activity outcomes.

Table 1. Participant characteristics at baseline.

	Total *M (SD)*	Control *M (SD)*	Intervention *M (SD)*	Difference Control vs Intervention *p**
N	695	342	353	
Female:Male	345:350	160:182	185:168	
Age (years)	13 (0.5)	13 (0.5)	13 (0.5)	.28
Height (cm)	159.6 (8.2)	160.0 (8.36)	159.3 (8.0)	.46
Weight (kg)	50.4 (11.4)	50.7 (12.0)	50.1 (10.8)	.73
BMI (weight/height in m^2)	19.7 (3.5)	19.7 (3.8)	19.6 (3.3)	.85
BMI z-score	0.32 (1.18)	0.29 (1.24)	0.36 (1.12)	.87
N	423	199	224	
Fat mass (%)	25.1 (8.0)	23.3 (8.2)	26.8 (7.5)	.06
Fat mass (Kg)	13.1 (6.5)	12.0 (6.5)	14.0 (6.3)	.17
Fat Free mass (Kg)	37.3 (7.0)	37.8 (7.4)	36.8 (6.6)	.17
N	460	226	234	
Physical Activity (CPM)	677 (200)	675 (189)	679 (209)	.68
Sedentary PA (%)	74.9 (5.6)	75.1 (5.2)	74.8 (6.0)	.76
Light PA (%)	22.8 (4.9)	22.6 (4.5)	23.0 (5.2)	.85
Moderate to Vigorous PA (%)	2.2 (1.4)	2.3 (1.4)	2.2 (1.4)	.58
Accelerometer wear-time T0 (min)	3278 (984)	3340 (926)	3224 (1032)	.60

Note: the analyses of baseline fat and PA measures exclude students whose baseline is missing, but these students are included into the effect analyses if they provide posttest data.
* Based on the mixed regressions with students nested in schools, using REML

Missingness analyses

To measure body composition, students handed in two urine samples at school. For the physical activity in daily life measurement, students wore an accelerometer for 5 consecutive days including two weekend days. Due to the nature of these measurements, many students decided not to participate in this measurement (either at T0, T1, or both, see Table 2), resulting in missingness. This is schematically displayed in Table 2; similar patterns of missingness are found in both the control and the intervention group.

Table 2. Missingness of body composition measurements.

Body composition measurement

			T1	
			Missing	Not Missing
Control	T0	Missing	119	24
		Not Missing	84	115
Intervention	T0	Missing	105	24
		Not Missing	94	130

Physical activity measurement

			T1	
			Missing	Not Missing
Control	T0	Missing	99	17
		Not Missing	124	102
Intervention	T0	Missing	104	15
		Not Missing	130	104

Participants with missing data at T0 and T1 could not be included in the mixed regression effect analysis. To check possible bias arising from this, the relation of such complete missingness (i.e. missing at T0 and T1 simultaneously) to condition, age, sex, level of education, baseline BMI, and the 'switch' variablea was checked with logistic regression (results are summarised in Additional File 1). Possible bias arising from how these baseline variables relate to complete missingness of an outcome was resolved by including all baseline variables as predictors into the effect analyses with mixed regression.23 The following baseline variables were related to complete missingness: 'switch' ($p = .04$ for body composition measurement and $p < .01$ for the physical activity measurement), level of education ($p < .01$ for physical activity measurement), and sex ($p < .001$ for physical activity measurement)

Effect of the intervention on body composition

After one year, a 1.6% fat mass difference was found in favour of the intervention group (p=.007); see Figure 1a and Table 3. In absolute terms, this reflected a 0.9kg difference in fat free mass (intervention condition >control condition; p = .041) and 0.7kg in fat mass (intervention condition < control condition; p=.054). Furthermore, and apart from these intervention effects, boys had a significantly lower fat mass percentage and absolute fat mass, and higher absolute fat free mass than girls at pretest (see the Sex-effect in Table 1). At posttest, these differences had further increased for fat mass percentage (-3.7%, p <.001), absolute fat mass (-1.9kg, p <.001), and absolute fat free mass (+3.9kg, p <.001), see the time by sex effect in Table 1. However, these differences were equal in both conditions (no time*sex*condition effect).

A three-way interaction was found for the effects of the intervention on weight (Time*condition*sex, see http://focusonstrength.net). The same analysis but split on sex showed

Table 3. Outcomes of the mixed multilevel regression models for dependent variable fat mass percentage, absolute fat mass (kg), absolute fat free mass (kg), and body weight[a]

	Fat Mass %		Fat Mass (Kg)		Fat Free Mass (Kg)		Body Weight (Kg)[c]			
							Boys[c]		Girls[c]	
	Estimate *(SE)*	95% CI	Estimate *(SE)*	95% CI	Estimate *(SE)*	95% CI	Estimate *(SE)*	95% CI	Estimate *(SE)*	95% CI
Intercept	-17.81 (6.56)**	4.9– 30.7	-17.79 (1.04)***	-19.9 – -15.7	-20.99 (6.17)**	-33.1 – -8.9	-42.51 (7.03)***	-56.3 – -28.7	-20.23 (5.82)***	-31.7 – -8.8
Time[b]	1.35 (1.89)	-2.4– 5.1	-0.99 (1.10)	-3.2 – 1.2	26.00 (6.13)***	13.9 – 38.1	23.60 (8.59)**	6.7 – 40.5	32.37 (6.76)***	19.1 – 45.7
Condition[b]	2.83 (1.02)*	0.1– 5.6	1.45 (0.78)	-0.5 – 3.4	-1.25 (0.77)	-3.4 – 0.9	-0.36 (0.58)	-1.5 – 0.8	-0.00 (0.72)	-1.8 – 1.8
Age	-1.57 (0.50)**	-2.6 – -0.6	-	-	2.62 (0.47)***	1.7 – 3.5	2.67 (0.54)***	1.6 – 3.7	1.28 (0.45)**	0.4 – 2.2
Sex[b]	-2.94 (0.56)***	-4.0 – -1.8	-1.37 (0.30)***	-2.0 – -0.8	1.81 (0.50)***	0.8 – 2.8	-	-	-	-
Level of education	-	-	-	-	-	-	-	-	-	-
BMI baseline	1.39*(0.08)**	1.2 – 1.6	1.55 (0.04)***	1.5 – 1.6	1.23 (0.07)***	1.1 – 1.4	2.98 (0.83)***	2.8 – 3.1	2.74 (0.07)***	2.6 – 2.9
Time*Condition	-1.59 (0.58)**	-2.7 – -0.4	-0.69 (0.36)	-1.4 – 0.0	0.93 (0.45)*	0.0 – 1.8	1.47 (0.63)*	0.2 – 2.7	-0.64 (0.53)	-1.7 – 0.4
Time*Age	-	-	-	-	-1.66 (0.44)***	-2.5 – -0.8	-1.35 (0.59)*	-2.5 – -0.2	-1.92 (0.48)***	-2.9 – -1.0
Time *Sex	-3.66 (0.58)***	-4.8 – -2.5	-1.86 (0.36)***	-2.6 – -1.1	3.90 (0.46)***	3.0 – 4.8	-	-	-	-
Time*BMI baseline	0.17 (0.09)	-0.0 – 0.3	0.21 (0.05)***	0.1 – 0.3	-0.14 (0.07)*	-0.3 – -0.1	-	-	-	-

Intraclass correlations (ratio of between-school variance to between+within-school variance) were (all between 0.01-0.10, for FM% (primary outcome): ICC = .04 at both T0 and T1).

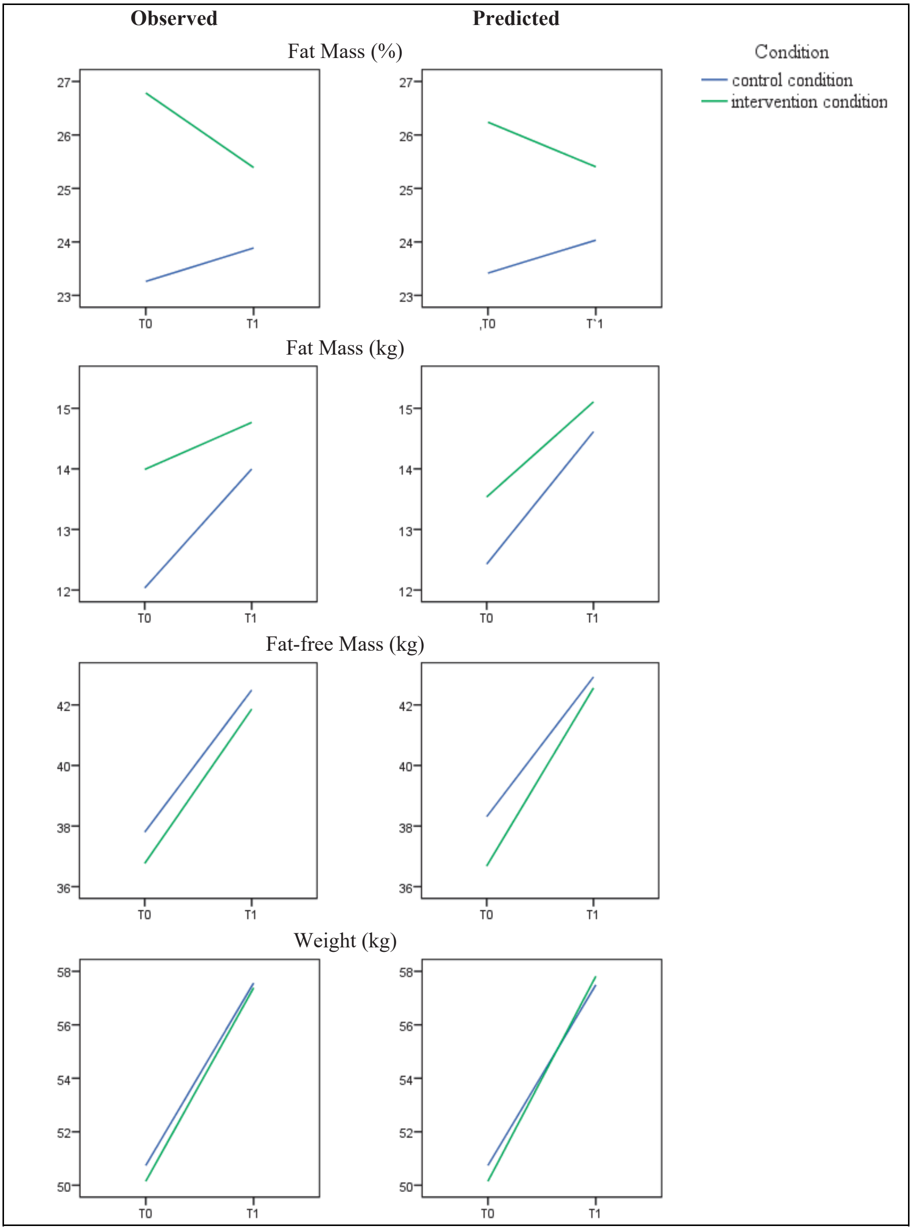
*p<.05; **p<.01; ***p<.001.

[a] The variables ‘Switch’ and switch x time were in the initial model (see Sample size and statistical analyses section, Footnote a). As these were not significant, these were excluded in the clean model as described in the table.

[b] Coding: Time (0 = T0, 1 = T1), Condition (0=Control condition, 1 = Intervention condition), Sex (0= girls, 1 = boys).

[c] For weight, a time*condition*sex effect was found (p = .005). Therefore, the effects for boys and girls are displayed separately in this table. The three-way interaction can be found in Additional File 1.

Figure 1a. Effect of the intervention on body composition



Body composition scores as measured by the deuterium dilution technique: Observed data, possibly biased by missingness (left panel), and predicted means based on the mixed regression (right panel).

that body weight increased substantially from pre- to posttest for boys and girls in both conditions. However, for boys the increase was 1.5kg more in the intervention condition than in the control condition ($p = .019$), due to an increase in fat free mass ($p = .07$). For girls, no significant change was found between conditions (-0.6kg, $p = .22$). Rerunning all final models without the condition term (which represents the baseline difference between conditions and must be zero apart from chance differences due to the randomization) gave very similar condition*time effects as the final models themselves, indicating robustness of these effects against baseline differences (Van Breukelen, 2006; 2013; see http://focusonstrength.net).

Effect of the intervention on physical activity behaviour in daily life

Daily PA decreased from baseline to posttest in both groups, but less so in the intervention group (p=.049; see Figure 1b and Table 4). The time-effect was not significant in the intervention-group (p =.490). After 1 year, no differences in sedentary behaviour (p =.715), or light physical activity (p =.833) were found between groups. After 1 year, a small but significant difference of 0.4% was found for moderate to vigorous physical activities in favour of the intervention group (p=.046). Rerunning the final models without the condition term did not substantially change the results for the condition*time effect of interest (Van Breukelen, 2006; 2013; see http://focusonstrength.net).

Discussion

Study outcomes

In a school-based randomised controlled trial, we have shown that small and easily implementable changes in secondary schools (minor adjustments to the physical education classes, plus physical activity motivation) can cause favourable differences in body composition in 11-15 year-old adolescents. After one year, a 1.6% fat mass difference was found in favor of the intervention group, reflecting a 0.9kg difference in fat free mass (intervention condition >control condition) and 0.7kg in fat mass (intervention condition <control condition). With respect to physical activity, all adolescents became less physically active after 1 year. This is a phenomenon that is seen more often in youth (Ruiz et al., 2011; Van Mechelen et al., 2000). However, due to the intervention, the physical activity level in the intervention group decreased much less as compared to the control group. The results found in this study might positively influence short-term and long-term metabolic health and chronic health risks.

The beneficial effects of improving body composition are twofold. First, it is well known that a higher fat percentage is related to several cardiovascular risk factors, such as increased triglyceride levels, higher LDL, lower HDL, increased blood pressure and insulin resistance, and that these associations already exist in children and adolescents. Secondly, increasing fat-free mass not only increases basal metabolic rate -- but also total energy expenditure (Plasqui et al., 2005) -- increasing the likelihood of weight loss.

Our results also indicate that the use of strength training at school alongside a motivational intervention can induce a change in activity levels, also outside physical edication classes. Several meta-analyses have shown a dose-response relationship between physical activity and cardiovascular disease and/or all-cause mortality showing that any improvement in physical activity behaviour may have large beneficial effects (Wen et al., 2011).

Strength training as a new approach

In this study, we bridged the gap between biological and psychological approaches to the management of obesity, showing that strength exercises have both physiological and psychological benefits for adolescents with overweight and obesity. By focusing on the general first year secondary school population, and not only on overweight or obese youngsters, we attempted to minimise any stigma associated with obesity and encourage interpersonal appreciation.

Table 4. Outcomes of the Mixed Multilevel Regression Models for Dependent Variable Physical Activity (in Counts per Minute; CPM), Sedentary Behavior (%), Light Physical Activity (%), and Moderate to Vigorous Physical Activity (%)[a]

	Physical Activity (CPM)		Physical Activity Sedentary %		Physical Activity Light %		Physical Activity Moderate to Vigorous %	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
	M (SE)	*M (SE)*	*M (SE)*	*M (SE)*	*M (SE)*	*M (SE)*	*M (SE)*	*M (SE)*
Intercept	807.34 (58.28)***	692– 923	72.32 (1.70)	68.9 – 75.7	23.25 (0.68)***	21.7 – 24.8	3.25 (0.38)***	2.5 – 4.0
Time[b]	-63.22 (18.31)***	-99 – -27	1.71 (0.56)	0.6 – 2.8	-1.52 (0.50)**	-2.5 – -0.5	-0.16 (0.13)	-0.4 –0.1
Condition[b]	-8.91(40.95)	-107 – 88	0.16 (1.26)	-2.8 – 3.2	0.03 (0.91)	-2.2 – 2.2	-0.14 (0.24)	-0.7 –0.4
Age	-	-	-	-	-	-	-	-
Gender[b]	66.46 (16.99)***	33 – 100	-0.97 (0.49)	-1.8 – -0.0	-	-	0.45 (0.11)***	0.2 – 0.7
Level of education	-	-	-	-	-2.20 (1.07)	-4.8 – 0.4	-	-
BMI baseline	-7.98 (2.48)***	-13 – 3	0.15 (0.07)	0.0 – 0.3	-	-	-0.06 (0.02)***	-0.1 – -0.0
Time*Condition	50.99 (25.75)*	0 – 100	-0.29 (0.78)	-1.8 – 1.3	-0.15 (0.70)	-1.5 – 1.2	0.38 (0.19)*	0.0 – 0.8

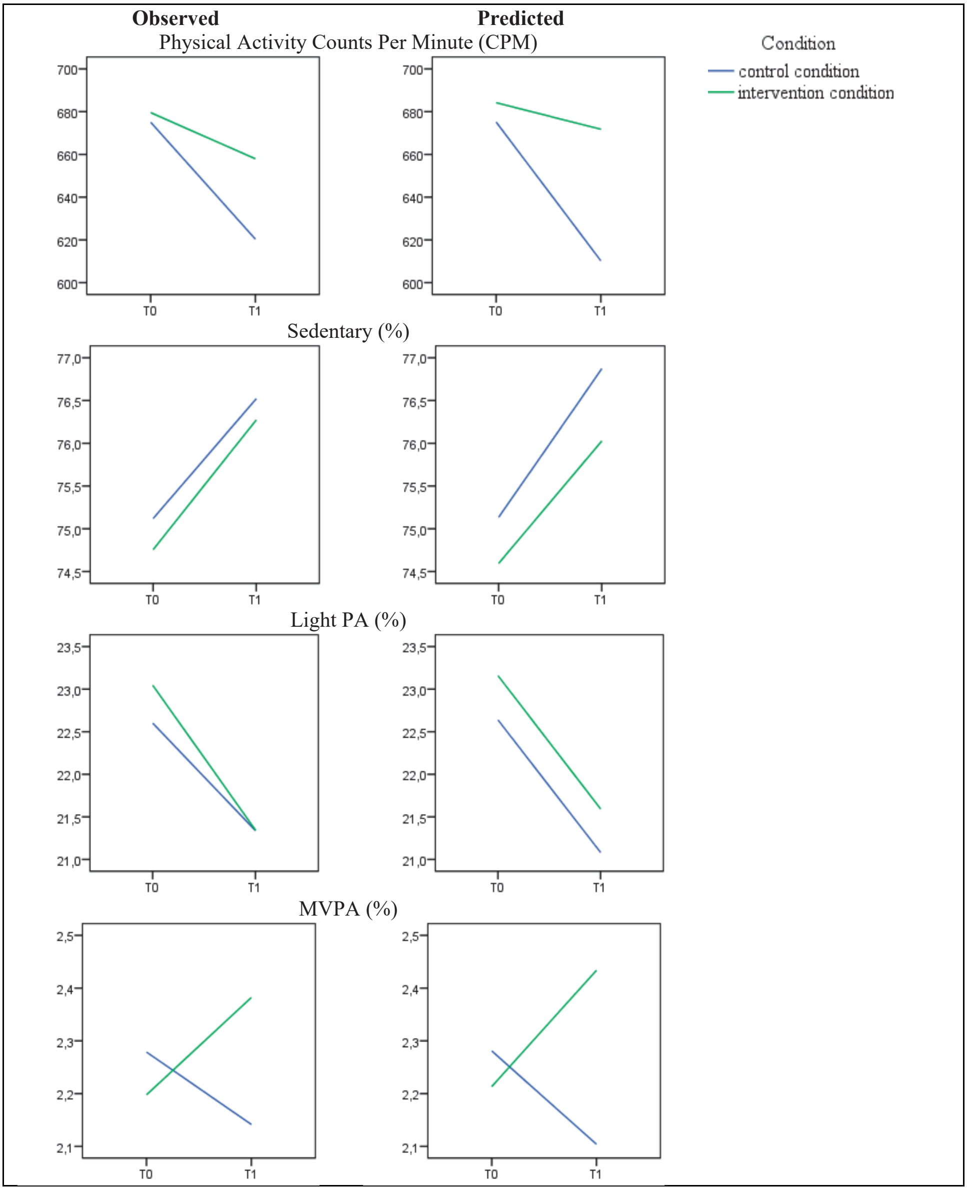
Intraclass correlations all between 0.01-0.10.

*p<.05; **p<.01; ***p<.001.

[a] The variables ‘Switch’, ‘Time*Switch’, ‘ ‘Time*Gender’, ‘Time*BMI baseline’ and ‘Time*Level of education” were in the initial model. As these were not significant, these are excluded in the clean model as described in the table.

[b] Coding: Time (0 = T0, 1 = T1), Condition (0=Control condition, 1 = Intervention condition), Gender (0= girls, 1 = boys).

Figure 1b. Effect of the intervention on physical activity



Physical activity measured by accelerometers: Observed data, possibly biased by missingness (left panel), and predicted means based on the mixed regression (right panel).

Our aim was not to reduce obesity per se, but to tackle obesity-related health issues. Our approach focuses on making overweight youngsters healthier (in terms of body composition) and motivating them to be more physically active. This was achieved, not by focusing on BMI, or the idea that overweight youngsters have to lose weight, but rather by focusing on their strength and on what overweight youngsters like to do.

Strengths and limitations

In this study we used highly accurate measuring techniques (deuterium dilution technique and accelerometry) in a relatively difficult setting (high schools). Although both measuring techniques (deuterium dilution and accelerometry) are acceptable in all age groups, the method is relatively expensive and thus often not applied in larger studies. Due to the nature of these measurements, many students decided to not participate in this measurement (either at T0, T1, or both, see Table 2 for exact numbers), resulting in missingness. However, this missingness is not higher than that found in other studies (Crutzen et al., 2013). While all available data were included into the analysis using a method that is valid under so-called missingness at random (MAR, missingness depends on observed variables such as age or pretest if posttest is missing), we cannot rule out bias arising from missingness not at random (MNAR, missingness depends on unobserved variables such as posttest if posttest is missing). Unfortunately, MNAR cannot be detected or adjusted for. At best, complex methods can be used to explore the robustness of results against various patterns of MNAR missingness (Verbeke & Molenberghs, 2000). Further, although our sample size was quite large, our study was underpowered both due to the larger than expected dropout or missingness and due to the clustered data structure (students nested within schools, randomization of schools).

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Process evaluation, diffusion and implementation

We have shown that strength exercises during physical education classes in secondary schools improve body composition and probably promote physical activity. At this point, it is difficult to estimate the magnitude of long-term effects. Replications of these findings are needed, but also diffusion and implementation. We have process evaluation data on secondary physiological and psychological outcomes, and are collecting data on teacher experiences with our programme; both will result in further suggestions to improve the intervention. Nevertheless, the basic idea is simple and easily implementable. Infrastructures at schools can be optimised. Physical education teachers can be informed about strength exercises, and provided with guidelines and suggestions for practice. A work book with exercises is freely available (see Additional File 1), but it was noticed that teachers themselves can easily come up with new ideas about strength exercises in the lessons the moment they understand the principle and find out that the students react positively, especially the students with overweight.

Outside the school setting, different sports in which pure physical strength and/or body mass are beneficial (eg. rugby, judo) could be systematically promoted as an alternative for youngsters who are overweight. Fitness centres offer strength training, but they are often inaccessible for youngsters, suggesting that a collaboration between schools and fitness centres may be fruitful. Schools could consider providing this equipment. Additionally, we recommend increasing parental awareness of the advantages of strength training in terms of their child's health.9,10 We do not want children and adolescents to become little body builders, nor should aerobic components be banned. Rather, we recommend that strength exercises, under qualified supervision, be added to a child's physical activity routine, asthey may well have positive long term health benefits.

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PART V
NOW WHAT?

Chapter 9
General discussion
Valorisation

In this dissertation, we have described 1) how we developed a prevention program targeting overweight and obesity, 2) how we performed a literature study and several cross-sectional studies to investigate whether our proposed ideas were correct, and 3) how we investigated the 1 year efficacy of incorporating strength exercises in gym classes, combined with monthly motivational lessons to engage in physical activities after school, on body composition and physical activity behavior of adolescents. We have shown that strength exercises during physical education classes in high schools improve body composition and probably promote physical activity. In this chapter, the overweight and obesity problem, the (development of our) program idea, and the results of our work will be discussed.

The obesity problem

Overweight and obesity in children and adolescents are seen as a global health challenge and a priority for prevention (GBD 2013 Obesity Collaboration, 2014). To solve a health issue such as overweight and obesity, we need full understanding of the related health behaviors (and underlying beliefs), and understanding of the biological mechanisms that cause or can prevent the issue. However, for overweight and obesity, drawing a full picture of the exact problem (and the subsequent solution) is difficult.

Not the long-term solution

A simplified idea is that children and adolescents who are overweight or obese are ‘just too heavy’ and that they ‘just have to lose weight’. As being too heavy (or becoming too heavy) is often a consequence of an imbalance between energy intake (food intake), and energy expenditure (physical activity, exercise, but also resting metabolic rate, and the cost of ingestion/digestion), the often-heard obesity-prevention adage is to eat less (and healthier) and to exercise more. However, to solve the obesity problem, it has repeatedly been proven that ‘just’ losing weight is a relatively easy, but incomplete and often only short-term solution.

By eating less (caloric restriction, diet) preferable short-term changes in body mass adjusted for height (BMI, used to determine weight status) can be achieved, but several bodily mechanisms often cause a fast weight regain. By quickly losing weight by caloric restriction, amongst others, one's energy expenditure also adjusts to a lower energy intake making long-term dieting a necessity for the maintenance of lost weight (Tremblay et al, 2013). At the same time, a proportionally high decrease of leptin levels (the ‘satiety hormone’), increased ghrelin levels (induces hunger), decreased peptide YY3–36, and cholecystokinin (induce satiety), and increased neural responsivity make people who quickly lose weight often surrender to a higher energy intake (Ochner et al., 2013). Another hypothesized cause of a fast weight regain is described in the screaming fat cell hypothesis: by quickly losing weight, the size but not the number of fat cells reduces. The adipocytes get ‘stressed’, and try to compensate by an increased uptake of glucose and fatty acids (Mariman 2012).

The other part of ‘eat less, exercise more’, being more physically active, might seem to be easier to achieve, except that it is often not. Overweight youngsters can often not compete with normal weight youngsters when it comes to aerobic exercises (Faigenbaum et al., 2009) and are more vulnerable to injuries when engaging in aerobic exercises (McHugh, 2010). Additionally, based on the unlikeliness that children or adolescents who are overweight or obese have mastery experiences when engaging in aerobic exercises, many psychological theories predict disadvantageous physical activity outcomes for those people. With lower relatedness, competence and autonomy when it comes to physical activity, Self Determination Theory (Deci & Ryan, 2010) suggests that the motivation to be physically active is often either absent (a-motivation), or extrinsic focused. Extrinsic motivation often results in potential short-term increased physical activity behavior, but not long-term. Based on negative past-performances, the Reasoned Action Approach (Fishbein & Ajzen, 2010) predicts lower physical activity attitudes, perceived norms or self-efficacy, resulting in lower intentions to be physically active, and a decreased physical activity behavior. As a result of worse physical activity performance compared to others, the Social Comparison Theory (Lemaine, 1974; Suls, Martin, & Wheeler, 2002; van Knippenberg, Wilke, & de Vries, 1981) suggests that this lower performance on a specific dimension (in this case: the physical activity dimension), will cause a shift in focus to other behavioral dimensions where superior performances can foster positive outcome expectations (for example: being better in guitar playing, or geography). Again, the result is a decrease in the physical activity behavior-level on the long term.

In conclusion, losing weight by eating less and being more physically active might be a short-term solution to being overweight or obese, but is often not the solution to overweight and obesity and its related diseases on the long term.

A very short, but still incomplete bigger picture

First, the focus should not be on weight, but on health: overweight and obesity are seen as a threat to an individual's health on physical and psychological level. These negative outcomes on individual level can lead to direct (health care; Mirza & Yanovski, 2014) and indirect (productivity or absenteeism) consequences on societal level (Grieve et al., 2013). All these negative outcomes might continue during and worsen throughout adulthood (Kelsey et al., 2014), and at some point, all these negative consequences should be targeted.

Second, related to the first point, the problem is not weight per se, but unhealthy weight: it has been shown that overweight and obesity related physical health issues often occur as a consequence of an unhealthy body composition (Dixon, 2010). Contrary, not one's body composition, but one's weight adjusted for height (BMI) is used to determine whether an individual has a healthy or unhealthy weight. Although BMI is a good and simple tool for risk estimates in large populations, it is not the right tool for individual metabolic and mental health evaluations (Bogin & Varela Silva, 2012) and might have stigmatizing effects on one's health in later life (Hunger & Tomiyama, 2014).

Third, the focus should not only be on the individual but also on the system: overweight and obesity are never caused by the individual solely but also by environmental levels (Kremers 2006; Bartholomew Eldredge et al., 2016): from people influencing overweight and obesity at most proximal environmental levels like the parents (Monasta et al. 2010; Cislak et al. 2012) or peers, to societal levels (see e.g., Borys et al, 2012 for an overview of the EPODE- approach)

Lastly, related to the previous points, weight loss interventions should become health interventions. Focusing on weight and weight loss might have stigmatizing effects, forming a threat to an individual's psychological wellbeing (Puhl 2009, 2015). Health care settings, including weight loss interventions are (unintentionally) a significant source of weight stigma. It is often believed that weight stigma triggers weight loss, but there is no evidence to confirm this belief (Puhl 2015). Directly related to this belief is the (wrong) assumption that weight loss is solely under one's own control, being a sufficient influence from the environment to produce change (Puhl, 2015). By focusing on health instead of weight, weight stigma might be reduced (or at least not induced).

A new approach

In our program, as outlined in this thesis, we proposed that there should be a focus on improvement of body composition instead of making overweight people leaner. Additionally, we suggest extra focus on mastery experiences within the field of physical activity, and optimal social comparison conditions (or in other words: we want to focus on what people *want* to do to become healthier instead of what they *have* to do).

In the currently proposed approach, the focus is on strength exercises in high schools to improve body composition in 12-15 year old adolescents. From a physiological perspective, it is known that youngsters who are overweight or obese are generally stronger in absolute terms i.e., they do not only have a higher fat mass, but also a higher fat-free mass. Therefore they are often better in strength related exercises compared to aerobic exercises *and* they are often better in strength exercises compared to their normal weight peers, making them – under the right circumstances – more motivated to engage in resistance exercise and ultimately maintain a physically active lifestyle. Additionally, strength exercises can improve body composition, i.e., an increase in fat-free mass and/or reduction in fat mass percentage. A higher fat-free mass will result in an increase in basal metabolic rate and total energy expenditure. In addition, a lower fat mass percentage improves several cardiovascular risk factors.

The intervention was executed in high schools. To reduce stigma, and to optimally use social comparison, the focus was not on weight or adolescents who are overweight or obese, but on health and on all youngsters. The physical education (PE) teachers integrated at least 15 minutes of strength exercises in their PE lessons. To motivate students to be more physically active after school, and to improve the determinants of their physical activity behavior, we included a motivational intervention (1-2 times per month). The motivational intervention challenged students to make their own decisions and choices and helped them through the process of self-regulation related to physical activity.

Main Findings

In considering strength exercises in health behavior change interventions targeting overweight and obesity, we used the Intervention Mapping protocol (Bartholomew Eldredge et al., 2016; Kok et al., 2016). We systematically mapped what is known about the differential psychological consequences of strength versus aerobic exercises. In a systematic literature research and meta-analysis (**Chapter 3**), we found that strength exercises may have positive effects on a number of psychological outcomes in people who are overweight or obese. These effects however, seemed often comparable to those of aerobic and diet interventions. The small and heterogeneous evidence base implied an urgent need for more research.

In a subsequent cross-sectional study (**Chapter 4**) we tested our chain of assumptions. We confirmed that heavier people have a higher fat-free mass compared to lean people. This was in line with biological insights. Additionally, we have shown that people with a higher fat-free mass are stronger (in absolute sense) and are better in strength exercises than aerobic exercises. We have also confirmed that mastery experiences (in this case, resulting from successfully engaging in strength exercises as opposed to aerobic exercises) improve psychological outcomes. This observation was in line with psychological insights. Moreover, heavier people are better in strength exercises, and enjoy strength exercises more compared to aerobic exercises. Finally, we have shown that heavier people enjoy strength exercises more than normal weight people, mediated by fat-free mass and

muscle strength. To the best of our knowledge, this was the first time that this chain of relationships has been demonstrated empirically.
Third, we examined parental attitudes about physical activity behavior in general and aerobic and strength exercises in particular (**Chapter 5**). Parents have a crucial role in their child's physical activity related behavior. Although strength exercises evidently have both physiological and psychological health benefits across all ages, they are erroneously considered to adversely affect health status in youngsters. We found that parents consistently reported a positive attitude towards aerobic exercises, but a less positive, neutral attitude regarding strength exercises. Parents indicated more often that their child was not allowed to participate in strength exercises than in aerobic exercises and considered strength exercises to interfere with optimal physical development. We suggested testing interventions to increase parents' understanding of the advantages of and possibilities (e.g., facilities) for strength training and the benefits of strength exercises on their child's health.

In our final cluster randomized controlled trial (**Chapter 8**) we examined the efficacy of a physical activity program combining strength exercises and motivational aspects in the school setting. Within the school setting, and by not only focusing on adolescents who are overweight or obese but on all adolescents, social comparison was optimally used and negative stigma was minimized. With the strength exercise focus, we aimed to improve body composition, and mastery experiences of adolescents who are overweight or obese. The motivational aspects focused on improvements in physical activity motivations and behavior in daily life. After 1 year, this study resulted in favorable changes in body composition and physical activity behavior in the intervention group compared to a standard curriculum control group. Based on our findings in this last study, and earlier performed studies, we concluded that strength exercises might be a valuable contribution to a child's physical activity possibilities and behavior.

Theoretical considerations

Intervention Mapping

The development of the Focus on Strength intervention was based on the Intervention Mapping (IM) protocol (Bartholomew Eldredge et al., 2016; Kok et al., 2016). With this, we described the iterative path from problem identification to problem solving or mitigation. The six steps of IM comprise several tasks each of which integrates theory and evidence. The completion of the tasks within a step created a product that guides the subsequent step. The completion of all of the steps served as a blueprint for designing, implementing and evaluating our intervention based on theoretical, empirical and practical information.

Interdisciplinary and ecological approach

Our approach was interdisciplinary; the program was developed with the help of scientists with many different expertises (e.g., biology, physiology, psychology, intervention development, health promotion, child health care). Also we included experts in the field (e.g., physical education teachers, school principals) and consulted motivational interviewing trainers, public health services and physical activity directors in municipalities.

Interdisciplinary research, as stated by *The Young Academy: Grensverleggend; Kansen en belemmeringen voor interdisciplinair onderzoek,* is often seen as nothing more than a 'multidisciplinary' combination of disciplinary perspectives. True interdisciplinarity goes a step beyond this; a crucial step. Interdisciplinary research characteristically involves a change in *scholarly identity*. This can be defined as ‘the interplay between the questions that researchers pose, the methods that they use, and the outcome measures that they employ’ (De Jonge Academie, 2015, p.7). The authors state that ‘a change in scholarly identity can have both beneficial and adverse effects and they have identified a number of major problems: the disciplinary focus of most funding bodies; the enormous time investment required to familiarize themselves with insights from outside their own discipline; cultural differences between disciplines; and friction with an academic infrastructure that is organized largely into disciplines, especially with regard to educational matters. There are good reasons to remove or at least minimize these obstacles. ‘Interdisciplinary research makes a major contribution to scientific innovation, leads to greater breadth and depth in individual disciplines, generates cross-disciplinary knowledge, and often plays a vital role in analyzing the major challenges facing society’ (De Jonge Academie, 2015, p.7).

In this project we managed to avoid most of the problems and to profit from the beneficial effects. The primary investigator was trained as biologist and psychologist and was able to integrate state of the art knowledge from both disciplines. The co-investigators contributed from biological, human movement, physiological, child health care, social psychological and health promotion sciences, without serious frictions. One binding factor was the societal relevance of challenges we face related to the obesity in youth.

Next to an interdisciplinary approach we applied a socio-ecological approach. Socio-ecological models suggest that intervention development should include (or at least consider) all possible stakeholders: not only at individual level, but also at environmental levels (Bartholomew Eldredge, et al., 2016): interpersonal, organizational, community and policy levels. Including parents into the program was considered (interpersonal level), but this was not directly necessary. However, future research and interventions are needed (see also *Future research and implementation*). It was decided to initially work with high schools and physical education teachers (organizational level) for three reasons: first, social comparison is part of typical class room settings and therefore unavoidable in the school setting (O’Keefe et al., 2013). Second, physical education teachers are aware of the benefits of strength training, are able to teach, or emphasize, the right techniques, and are able to provide qualified supervision. Third, when adolescents participate in strength exercises in high school and have positive experiences, they could discuss this with their parents, possibly curving their parents’ attitudes into a more positive direction. For the future, developments at the organizational and policy level will become relevant, such as training of physical education teachers as well as activities initiated at the city level to promote exercise behavior in children and adolescents (see *Future research and implementation*).

Social comparison theories

We developed a program for adolescents wh oare overweight or obese, but involved non-overweight peers for social comparison purposes (interpersonal level; note that also the non-overweight peers benefitted from the program.) We did not suggest promoting ‘outperforming others’, but promoting ‘mutual appreciation’, both related to social comparison theory and self-determination theory (relatedness). Outperforming others might relate to more controlled types of motivation, while a positive comparison with others for youngsters who are used to only experiencing negative comparisons might result in more autonomous motivations The relation between social comparison and self-determination is an under-investigated area. Some authors (e.g., Ames & Archer, 1988) have suggested that stimulating social comparison may have detrimental effects on autonomous motivation. However, O'Keefe et al. (2013) suggest that social comparison is part of typical classroom settings and therefore unavoidable. Moreover, Senko et al. (2011) argued that normative-based performance goals often facilitate classroom achievement. Standage et al. (2003) found that perceptions of competence and relatedness are more predictive of self-determined motivation than autonomy, but also that normative feedback that is repeatedly negative will lead to a-motivation. We think that, next to promoting autonomy (e.g., by giving youngsters choices; Deci & Ryan, 2000), positive social experiences of overweight youngsters with resistance exercises may increase their relatedness, perceptions of competence, their self-worth, and in time, their intrinsic motivation for exercise. In this intervention, having youngsters compete as teams in multi-component exercises might have encouraged interpersonal appreciation of various skills (e.g., speed vs strength). However, the relation between social comparison theory and self-determination theory has rarely been studied empirically (Neighbors & Knee, 2003).

The theory of expanded, extended and enhanced opportunities

Recently, Beets and colleagues (2016) argued that the focus of physical activity interventions should be on expanding opportunities to be physically active, extension of available opportunities to be physically active, and/or enhancement of the physical activity possibilities and/or opportunities. Their *Theory of Expanded, Extended and Enhanced Opportunities* (TEO) succeeds in making physical activity behavior more understandable and adds to the bigger picture of understanding obesity and obesity related behaviors. In our program, we have added the idea of '*Enriched Opportunities'* of currently available physical activities: we replaced good physical activities by (for people who are overweight or obese) better ones. This has been done, prior to expanding, extending, or enhancing the current physical activity opportunities.

Methodological considerations

In each step of the iterative process, decisions were made, influencing subsequent steps in the process, or sometimes even impacting the entire direction of the research.

Study populations

In our cross-sectional study, linking the biological outcomes with the psychological outcomes, only young adults (18-30 years of age) were included, even though our main focus in our program was on young adolescents aged 12-15 years (Chapter 4). The measurements during this study were mostly golden standard measurements, but also considered as being of high intensity, too invasive, difficult or not validated, or even health threatening for youth during growth (Dietz & Bellizzi, 1999). Less reliable measuring instruments could have been used in young adolescents (as opposed to young adults). However, as we assumed that the mechanisms would have been the same in youngsters vs. young adults, we chose to examine the relationships between the biological and psychological outcomes in young adults, with golden standard outcomes.

Initially, the idea of adding strength exercises to an adolescent's physical activity was focused on people who are overweight or obese only. Therefore, we first focused on performing our experimental studies in a clinical setting. During the process, and while the program ideas evolved, it was decided to shift our focus from the obesity clinic to a setting where social comparison played a larger role (see also theoretical considerations). Because of this shift, we were not able to perform a classic randomized controlled trial at the individual level, but were forced to cluster in groups of participants. With $\alpha = 0.05$, power = 0.90, and an assumed small to medium effect size ($d = .35$), 172 participants per group were needed for a classical RCT. However, in view of the clustering of students within schools and randomized assignment of schools (cluster randomized trial) a sample size of 600 was aimed at to adjust for the design effect arising from clustering (Van Breukelen & Candel, 2012). The sample size was further increased to 700 to accommodate 15% dropout (although all available data from all participants would be included into the analysis). Although our sample size was quite large, our study was underpowered both due to the larger than expected dropout or missingness and due to the clustered data structure (students nested within schools, randomization of schools; see also measurement issues).

Due to our shift, and our adjusted aims, we did not focus only on adolescents who are overweight or obese but on all adolescents (all adolescents would benefit from our program if effective, including adolescents with a higher BMI). However, in this approach we were able to take baseline BMI into account as covariate during our analyses to examine differential effects of the intervention due to weight differences. To recruit a population with a slightly higher BMI, we recruited mostly at schools with Lower Vocational Education. These schools are often characterized by adolescents from lower SES households and having a higher BMI. There is a possibility that the baseline characteristics and intervention effects are different when measured in other populations.

Measurement considerations

The shift from a clinical setting to high schools also caused a shift in the methods that were used for our evaluative measurements. Although golden standard techniques were preferred, these were often too expensive, or difficult to execute in larger populations. It was, important to be able to measure both body composition and physical activity behavior (our primary outcomes, reported in this thesis), but also strength, aerobic capacity, and psychological determinants in large groups of 11-13 year old adolescents in the school setting (secondary that will be reported later). All measurements were chosen based on a combination of their burden to the participants, validity, and reliability.

Body composition. Although there are many techniques to measure body composition, (e.g., DXA, hydrostatic weighing, air-displacement plethysmography, deuterium dilution and multi compartment models, see also Ellis, 2000; Simmonds, 2016) many of those techniques are costly, time consuming, and logistically challenging to use in large groups of children and adolescents (Brook, 1971, Simmonds, 2016). Additionally, these methods rest on assumptions by which raw data are converted to final values (Wells, 2006) by use of hydration factors (e.g., Lohman 1989), or fixed densities of fat- and lean mass (Durnin &Rahaman, 1967).

In our program, we used both the skinfold measures and the deuterium dilution technique (not reported in **Chapter 8**. As soon as these results are available, they appear at http://focusonstrength.net). Skinfolds are a simple, safe, non-invasive and widely used technique to measure body composition in larger groups of children and adolescents (Wells 2006; Brook 1971). Originally, skinfold measures were used to estimate body density (using body density regression equations derived from golden standard techniques, see e.g., Durnin & Rahaman, 1967; Durnin & Wommersly, 1974), after which Siri's equation (1956) was used to calculate fat- and fat-free mass. However, equations are population specific, and during maturation, the relation between skinfold thickness and one's subcutaneous adipose tissue distribution strongly depends on biological age (Boileau, 1981; Frerichs, 1979;Sarría, 1998). Measuring body composition by skinfolds is an indirect method. The measurement might suffer from additional errors while collecting the data.

Wells a Fewtrell (2006) describe that intra- and interobserver error are low compared to between-subject variability, but higher in obese youngsters. The assessment errors increases when a) the collected skinfold data is converted to body density or (in this case) total body water, and b) this data is converted to fat- and fat-free mass using hydration factors (e.g., Lohman 1989), or fixed densities of fat- and lean mass (Durnin &Rahaman, 1967).

The more sophisticated method that we used is deuterium dilution (Ellis, 2000; Schoeller et al., 1986). Compared to underwater weighing (which is still considered a gold standard measurement), deuterium dilution is a reliable method to assess fat mass percentage in normal weight and obese subjects (Westerterp, 1991), showing the same changes in fat-free mass over time (Van der Kooij, 1992). Although relatively expensive (and thus often not applied in larger studies), this technique was most suitable in our study (i.e., simple, non invasive, minimal subject cooperation; Wells, 2006).

Strength measurement. The most frequently used method to measure strength is the handgrip dynamometer because of its cost effectiveness, simplicity, and portability (Fess, 1987). However, movement patterns performed during the execution of the handgrip test are not comparable to movement patterns of larger muscle groups, or performed in daily life or exercise training programs (Abernethy et al., 1995). To partly overcome this limitation, we evaluated the back-leg-chest (BLC) dynamometer as an effective, simple and portable way to test total body strength. The apparatus induced execution of static contractions, which are required less often in daily life compared to dynamic contractions. The BLC dynamometer provided reasonably reliable test-retest measurements of BLC strength in healthy adolescents and adults and was therefore considered an appropriate tool to evaluate changes in muscle strength in our study.

Physical activity in daily life. For physical activity in daily life, the Actigraph GT3X accelerometer was used. Although this was a relatively simple measurement with a low burden to participants compliance was lower than expected: some students forgot to wear the accelerometer (especially during weekend days), and some complained that they didn't like to wear the elastic band with device because it did not match their choice of clothing, it hurt their back, or was irritating in another way.

Questionnaire considerations. To keep the length of the questionnaire relatively short, it was chosen to include questions relating to the Reasoned Action Approach, Self Determination Theory, and Social Comparison, as these were considered in our intervention development. Although it would have been interesting to include other, clinical outcome measures (e.g., quality of life, self-esteem, mood, stress, as found in our review in **Chapter 3**), this would have increased the length of the questionnaire substantially, and with that the burden on the participants.

Aerobic capacity considerations. To measure aerobic capacity, the shuttle run test was used. The shuttle run test has a moderate-to high validity for estimating maximum aerobic capacity (Mayorga-Vega et al., 2015) Although this measure can easily be executed in larger groups, the test is an estimation and does not directly measure aerobic capacity. Individual performances are prone to their motivations, and to other's performances. Submaximal and maximal tests using treadmill, or cycle ergometer, or tests where heart rate monitors were required were seen as unreachable in the classroom setting. Compared to the Coopertest (where students are asked to run for 12 minutes and where the distance was used as proxy for aerobic capacity), the shuttle run test was less likely to be influenced by weather conditions.

Missingness because of the intensive measurements

Although both our main outcomes (i.e., body composition and physical activity behavior) measuring techniques (deuterium dilution and accelerometry) are accurate, and acceptable in all age groups, the method is relatively expensive and thus often not applied in larger studies. A limitation of these measurements is that, due to the nature of these measurements, many students decided to not participate in this measurement (either at T0, T1, or both), causing missingness. While all available data were included into the analysis using a method that is valid under so-called missingness at random (MAR, missingness depends on observed variables such as age or pretest if posttest is missing), we cannot rule out bias arising from missingness not at random (MNAR, missingness depends on unobserved variables such as posttest if posttest is missing). Unfortunately, MNAR cannot be detected or adjusted for. At best, complex methods can be used to explore the robustness of results against various patterns of MNAR missingness (Verbeke & Molenbergh, 2009).

Future research and implementation

We have process evaluation data on secondary physiological and psychological outcomes and are collecting data on teachers' experiences with our program. Besides this, and for a long-term effective strength-based physical activity program, there are still several questions that need to be answered.

Future research

Psychological behavioral determinants. From our systematic review and meta-analysis, we concluded that strength exercises are a viable alternative to or addition to diet and/or aerobic interventions when it comes to improving psychological outcomes, but more research is necessary. In the literature, studies reported only on a limited range of psychological outcomes. The reported psychological outcomes were mostly clinical outcomes or markers of quality of life. Measuring self-determination concepts as psychological constructs might give additional information about the effects of exercise training to be considered alongside that obtained from current clinical and quality of life measures.

Feedback and body composition. We also suggested giving feedback on body composition instead of weight loss to improve psychological outcomes. Pescud and colleagues (2010) reported that feedback on body composition is useful as a 'surrogate' for feedback on weight loss, which motivated participants to continue participating in strength training exercises. Gaining strength, and ultimately obtaining a healthier body composition, might lead to a higher resting metabolic rate, increased total energy expenditure, and a decreased chronic diseases risk (Dixon, 2010). Thus, when participants in a strength training program become stronger, this should also lead to (long term) positive changes in body composition and health. However, these positive effects are often not reflected in reported short-term psychological outcomes of strength training as compared to other interventions. Related to this, two more recommendations for future research arise. First, as described under **theoretical considerations**, the relation between social comparison theory and self-determination theory has rarely been studied empirically (Neighbors & Knee, 2003), and needs to be further investigated. Second, valid and reliable methods to measure body composition should become more accessible to the public. Although there are many proper techniques to measure body composition available (e.g., DXA, hydrostatic weighing, air-displacement plethysmography, deuterium dilution and multi compartment models, see also Ellis, 2000; Simmonds, 2016) many of those techniques are costly, time consuming, logistically challenging to use in large groups, or for personal use (Brook, 1971, Simmonds, 2016).

Parental attitudes and influence In the study examining parental attitudes regarding strength training, we concluded that future interventions should increase parent's understanding of the advantaged and possibilities (e,g., facilities) of strength training on their child's health and that strength training can be fun. Without parental support, it will be more difficult for (overweight) youngsters to engage in resistance exercises (Davison et al., 2013).

Tailoring. Further research is required on how possible program characteristics (e.g., intensities, quantities, form of exercise, feedback mechanisms) can be tailored to the individual (e.g., for the same exercise, an overweight adolescent lifts a heavier weight than a lean adolescent) or group level (e.g., girls may prefer other resistance exercises than boys, Biddle et al., 2014).

Replication. Lastly, future randomized controlled trials should replicate our findings and evaluate the immediate and long-term effectiveness of our approach. This can be done in high schools, but also in other settings and age groups (e.g., primary schools, clinical setting).

Implementation

The basic idea of our approach is simple and easily implementable. For future implementation infrastructures at schools (including the playgrounds) can be optimized (not only in high schools, but also in primary schools).

For the future, developments at the organizational and policy level will become relevant, such as training of physical education teachers as well as activities initiated at the city level to promote exercise behavior in children and adolescents. Physical education teachers can be informed and educated about the background of the strength exercises, with guidelines and suggestions for practice. A work book with exercises is freely available but it was noticed that teachers themselves can easily come up with new ideas about strength exercises in the lessons the moment they understand the principle and find out that the students react positively, especially the students with overweight.

Outside the school setting, different sports in which pure physical strength and/or body mass are beneficial (eg. rugby, judo) could be systematically promoted as an alternative for youngsters with overweight. Fitness centers provide strength training possibilities but they are often not accessible for youngsters. In the future, schools may collaborate with fitness centers to create optimal circumstances, or schools themselves may provide fitness equipment for their students.

Conclusions

We developed a program that influences body composition and physical activity. This might not be a direct solution to combat obesity, but it might help in the long-term prevention of obesity related health issues. We suggest adding strength exercises to a child's physical activity possibilities: as long as strength exercises are performed under qualified supervision, they might have positive long-term health benefits.

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Valorisation

It was February 2017, and I was at a symposium in Sydney (Australia). After one of the many presentations, a simple question from the crowd was "So, what can we do with the results of your study*?" - The well-respected professor from the University of Toronto (Canada) decided to explain the purpose of his work by saying "*I study behavior, I don't improve it". *That was the moment I decided to leave…*

Our 'So, what?' question.
For each scientific study, the 'So, what..?' question needs to be answered in a satisfying way, even when the answer is obvious and clear. Therefore, in this section, the focus is on *valorisation.* In simple terms - and in its broadest definition - valorisation emphasizes on how the results and knowledge derived from scientific research can be of value for society. The products can be diverse and limitless: from all forms of publicity to transfer the knowledge, to commercially available merchandises. In this section, I will focus on (or limit myself to) knowledge transfer, the possible influence of our program on the costs of obesity, the valorisation possibilities for strength exercises, and motivation. At the end of this paragraph a few considerations that needs to be taken into account for all ***Focus on Strength*** valorisation steps will be discussed.

The overall purpose of our studies was that we tried to contribute to solving overweight and obesity related health issues. For this, we first tried to understand the biological determinants that cause or prevent the issue, and the psychological determinants that cause or prevent the related health behaviors (and underlying beliefs): a combination of biological knowledge and psychological insights. Our idea was that youngsters who are overweight or obese are better in strength exercises compared to aerobic exercises *and* are stronger compared to their normal weight peers. From a psychological perspective, this can make them more motivated to engage in strength exercise and to ultimately maintain a physically active lifestyle. From a biological perspective, strength exercises can improve body composition and health.

From knowledge transfer…
For valorisation purposes and as a researcher in general, we see it as our duty to inform others, not only of our successes, but also our failures. One of the principles is that all my work is open, transparent, and therefore replicable. I have attended multiple (inter)national congresses and symposia, and publish our (both National and International) work (available via http://focusonstrength.net**)**. All research and program materials, data, analyses and output are always fully disclosed (when applicable).

…To a reduction of life time costs of obesity…
Obesity has many health and quality of life consequences which might continue during and worsen throughout adulthood (Kelsey et al., 2014). These consequences can be translated to costs to direct (health care; Mirza & Yanovski, 2014) and indirect (productivity or absenteeism) consequences on a societal level (Grieve et al., 2013). Careful estimates of the life time costs were found to be over 90.000 US Dollar (approximately 81.000 euro) greater for a person who is obese versus a person without overweight (Kasman et al., 2015). In our research, we did not focus on losing body weight, but decided to concentrate on improvements in body composition. Applying the strong theoretical

base and the small but significant body composition improvements after 1 year as found in **Chapter 8** might reduce these costs and advocates larger scale implementation.

…To strength exercises as product…

The idea of adding strength exercises to one's daily life creates many possibilities for valorisation. With more emphasis on strength exercises, we do not want children and adolescents to become little bodybuilders, nor that aerobic components should be banned. Rather, we recommend that strength exercises, under qualified supervision, should be added to a child's physical activity routine.

To increase the strength exercise possibilities for children and adolescents, first infrastructures at schools should be optimised. A workbook with exercises is freely available (see http://focusonstrength.net). This product should be further developed and spread with the help of teachers and professionals (e.g. Kennis Centrum Sport/Knowledge Center Sport). Physical education teachers can be informed about and/or trained in strength exercises, and provided with guidelines and suggestions for practice. For this, developments are needed at the organizational level, such as inclusion of strength exercises and the benefits of social comparison in the training of physical education teachers. Developments at policy level are needed to initiate activities at municipal level to promote strength exercises in children and adolescents. Outside the school setting, different sports in which pure physical strength and/or body mass are beneficial (e. g. rugby, judo) could be systematically promoted and/or developed for youngsters who are overweight. Fitness centres offer strength training, but are often inaccessible for youngsters, suggesting that collaborations between schools and fitness centres may be fruitful. School managements could consider providing this equipment.

…To motivation as product.

In our program, to motivate students to be more physically active after school, and to improve the determinants of their physical activity behavior, the basic principles of Motivational Interviewing were applied. For valorisation purposes the motivational program component could be further developed and improved. We have process evaluation data on secondary physiological and psychological outcomes, and are collecting data on teacher experiences; both will result in suggestions to improve the intervention. The motivational program as product can be distributed in secondary schools and other educational settings.

Considerations for further valorisation.

Although strength exercises may have both biological and psychological benefits in the obesity 'challenge', other aspects need to be considered for valorisation and implementation. Some of our decisions are directly related to the conditions that need to be considered before using our knowledge optimally. For example, we decided to initially work with high schools and physical education teachers for three reasons: first, social comparison is part of typical class room settings and therefore unavoidable in the school setting (O'Keefe, Ben-Eliyahu, & Linnenbrink-Garcia, 2013). Second, physical education teachers are aware of the benefits of strength training, are able to teach, or emphasize the right techniques, and are able to provide qualified supervision. Third, parental awareness of the advantages of strength training in terms of their child's health needs to be increased (see **Chapter 5**), and this can be done via the children: when adolescents participate in strength exercises in high school and have positive experiences, they could discuss this with their parents, possibly curving their parents' attitudes into a more positive direction. Without parental support, youngsters (who are overweight) will not engage in strength exercises (Davison et al., 2013) outside the school setting.

The focus on strength intervention can be implemented in multiple settings, and translated to multiple products, but for each implementation setting or product, the following aspects need to be considered:

1. Implementers and related stakeholders need to be positive, or at least neutral about the product. For example, in settings where parents are more involved in their child's physical activity behavior, the parents need to be motivated first **(see also Chapter 5)**. In our current program, the school management is an important stakeholder for this intervention. Commitment from the school management was therefore essential to optimize communication with parents and within the school, and with that to optimise the support from the teachers. Moreover, involvement of the school management was important in order to make this program part of the regular curriculum of the school. Therefore, regular meetings with school managements guaranteed proper participation from the schools and improvement the study.
2. An important consideration for social comparison – which might trigger overweight people to become more physically active when there is a strength aspect involved – is not only that overweight youngsters are better than normal weight youngsters, but also that overweight and normal-weight youngsters exercise together, and that there is a mutual appreciation between the youngsters in each other's performance. It is evident that when normal-weight youngsters and youngsters who are overweight are not physically active together, there is no social comparison, as youngsters who are overweight will not find out that they in fact perform better than normal-weight youngsters. Also, when there is no mutual appreciation (e.g., normal-weight youngsters attribute the better strength performance of youngster who are overweight to 'because they are heavy' and not to 'because they are strong'), the positive effects of the social comparison are devaluated. A possible manner to accomplish this is to develop a physical activity team-task with both aerobic and (absolute) strength components, wherein the team (and not the individual) will be evaluated per task at the level of the best team member (which is most satisfying for all group members; Forsyth, 2014). Because youngsters work in teams, the focus is on performance and not on weight. With that, also the level of stigmatization is limited to a minimum (Hunger & Tomiyama, 2014).
3. Collaboration is a must. Obesity is a multidisciplinary problem, and a multidisciplinary approach is needed. Therefore, it is not only important that scientists with expertise in different areas work together, but also governments and industries collaborate.
4. Not only in our current work, but also for future implementation and valorisation, the aim should be on practical and applicable science to aid social value. Together with the implementers, the line between which intervention components are feasible and which are not should be investigated. For example, to gain a better body composition, our intervention required a sharper focus on strength exercises in physical education lessons, resulting in the students spending at least 30 % of the PE lessons on strength exercises (an average of approximately 15 min per lesson). The choice for 30 % was the outcome of meetings with PE teachers about the feasibility of integrating strength exercises in their standard curriculum.

Conclusions.

There are limitless options for valorisation of the ***Focus on Strength*** components**.** Within this program we do not have to solve obesity per se, but obesity-related health issues. On many levels, we showed that strength exercises might contribute to this solution. Our approach has the abilities to make overweight youngsters more (motivated to be) physically active, and more healthy by means of a healthier body composition; not by focusing on the current aerobic-focused physical activity guidelines, one's BMI, or the idea that overweight youngsters have to lose weight, but by focusing on their strength and on what overweight youngsters like to do.

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Summary

In **PART I THE INTRODUCTION TO AN IDEA** of this dissertation, we introduce the rationale behind the ***Focus on Strength*** program in more detail: in **Chapter 1** with a more biological perspective, in **Chapter 2** with a more psychological perspective.

In **Chapter 1**, the biological perspective, we emphasized the importance of combining both biological and psychological knowledge. More and more children are obese, and obese children become obese adults. In our approach, we suggested that strength exercises might be an important aspect in the treatment and prevention of childhood obesity. When looking at body composition, overweight youngsters do not only have a higher fat mass, but also a higher muscle mass compared with their normal-weight counterparts. With that, they are also stronger and better in exercises wherein the focus is on absolute strength, making them – under the right circumstances – more motivated to engage in resistance exercise and ultimately maintain a physically active lifestyle.

One reason that overweight youngsters are not physically active is that they are outperformed by normal-weight youngsters, and one reason they are overweight is because they are not physically active. To break this vicious cycle, we first have to shift our focus away from body weight adjusted for height (BMI) as an individual metabolic and mental health measure. Furthermore, instead of the focus on making overweight people leaner – which might be stigmatizing – there should be a focus on improvement of body composition in all youngsters. Finally, instead of focusing on the present physical activity guidelines, we suggest that it might be more appropriate to focus on health behaviors people like to do. To break the cycle, resistance exercises might be the solution.

In **Chapter 2**, the psychological perspective, we have argued that new physical activity directions for overweight and obese youngsters might benefit by a stronger emphasis on resistance exercises, whereas a motivational intervention might stimulate them to engage in these exercises. In our view, it was time to start using psychological principles and techniques to make youngsters aware of their strengths. Only then long-term behavior changes and long-term health benefits may be achieved. Compared to normal weight youngsters, overweight youngsters are less capable of performing at a desired or comparable level in aerobic exercises. These negative experiences may result in disinterest and a loss of motivation. We expected that overweight youngsters will notice that resistance exercises are easier than aerobic exercises and that their performance will be better than the performance of their normal weight counterparts. As a consequence, their enhanced feelings of competence may induce an increase of autonomous motivation for physical activity, which is required for sustained behavior change. To make overweight and obese youngsters healthier, stronger, more confident (and feeling better in general), resistance exercise may be the fruitful way to go.

Although we were convinced of our ideas - strength exercises seemed to be a fruitful way to go - not all assumptions were scientifically tested, and niches in our knowledge needed to be filled. These are addressed in **PART II THE RIGHT TRACK CHECK**. ‘

In **Chapter 3**, we examined the current knowledge of ‘the psychological strengths of strength exercises’ in people who are overweight or obese with a systematic literature research. Relevant literature was identified by use of the PubMed and PsycINFO databases. Seventeen studies were included. There was almost no overlap among the various measures of psychological constructs. The constructs were ordered into eight broad categories. Meta-analytical techniques revealed substantial heterogeneity in effect sizes, and combined with the low number of effect size estimates for each outcome measure, this precluded meta-analysis. Organization of the data showed that the evidence base so far does not show convincing effects of strength training on psychological outcome measures. Some weak effects emerged on self-efficacy, self-esteem, inhibition, and psychological disorders (e.g., anxiety and depression). No additional or comparable effects to other interventions were found for mood, outcome expectations, quality of life, and stress.

The main finding of this review is that despite a strong theoretical basis for expecting positive effects of strength training on psychological outcomes, the literature shows a large gap in this area. The existing research does not show a clear picture: some positive results might exist, but there is a strong need to accumulate more evidence before drawing conclusions.

In **Chapter 4,** we bridged the gap between biological and psychological insights in the management of obesity, by examining the putative physiological and psychological benefits of strength exercises. In this cross-sectional study the main hypothesis was that heavier people enjoy strength exercises more than normal weight people, mediated by fat-free mass and muscle strength. Further, it was hypothesized that heavier people are better in strength exercises, and enjoy strength exercises more compared to aerobic exercises. We measured height, weight, body composition (i.e. fat- and fat-free mass by underwater weighing), muscle strength (i.e. one repetition maximal strength for the leg press and chest press), maximal aerobic exertion (VO2max) during cycle ergometry, and psychological determinants (i.e., attitudes, intentions and self-determination motivations for strength exercises and aerobic exercises using questionnaires) in 68 participants (18-30 years). Significant correlations between weight/BMI and fat-free mass (index) (r's = .70 - .80, p's <.001), fat-free mass and muscle strength (r's = .35 - .55, p's <.05), and muscle strength and attitudes, intentions, and motivation for strength exercises were found (r's = .29- .43, p's <.05). BMI was related to psychological determinants via fat- free mass and muscle strength. Furthermore, participants with a higher BMI, were significantly better in strength exercises more intrinsically motivated, and less a-motivated to do strength exercises compared to aerobic exercises, (all p's <.05). Trends in the same direction were found for the variables instrumental attitude, experiential attitude, and intention (p's < .1). We confirmed that strength exercises could be more appreciated by heavier people and might therefore be a valuable component in physical activity programs for people with overweight or obesity.

Lastly, in **Chapter 5**, we examined parental attitudes about physical activity behavior in general and aerobic and strength exercises in particular. Although strength exercises evidently have both physiological and psychological health benefits across all ages, they are erroneously considered to adversely affect health status in youngsters. In total, 314 parents from an online panel representative of the Dutch population completed an online survey about their own physical activity and that of their child (12–15 years old). The study also explored reasons for non-participation, and attitudes about the parents' own and their child's physical activity level. Parents consistently reported a positive attitude towards aerobic exercises, but a less positive attitude regarding strength exercises. Parents were more likely to indicate that their child was not allowed to participate in strength exercises (29.6 %) than aerobic exercises (4.0 %). They thought that strength exercises could interfere with optimal physical development. We suggested testing interventions to increase parental understanding of the advantages of and possibilities for (e.g., facilities) strength training on their child's health.

After we found out that we were on the right track in Part II, we continued to develop an intervention program based on strength exercises **(PART III THE DEVELOPMENT OF AN INTERVENTION)**.

In **Chapter 6** we evaluated the back-leg-chest dynamometer - as an effective, simple and portable way to test total body strength. The most frequently used dynamometer is the handgrip dynamometer because of its cost effectiveness, simplicity and portability. However, movement patterns performed during the execution of the handgrip test are not comparable to movement patterns of larger muscle groups, or performed in daily life or exercise training programs. To overcome this limitation we assessed the test-retest reproducibility and smallest real difference (SRD) of the BLC dynamometer in healthy adults and adolescents and examined whether handgrip, knee-extensor and knee-flexor strength predict BLC strength in healthy adults. Forty-five adults and 58 adolescents were recruited. In a first session back-leg-chest strength, handgrip strength, and additionally, in adults, isometric knee-extensor strength, and knee-flexor strength were measured. In a second session, 2-5 days later, BLC strength was measured again for test-retest reproducibility. Inter-session correlations of BLC strength were high (all r's and ICC's > 0.92). Bland-Altman-plots showed high agreement. The SRD and SRD% were between 14-26, and 19% and 26% respectively. Strength variables (handgrip, knee-extensor, and knee-flexor strength) explained 87% of the variance in BLC strength. A stepwise linear regression showed that dominant knee extensor and flexor strength were the most important significant predictors of BLC strength ($r2 = 0.86$). This study demonstrated that the BLC dynamometer has reasonably high test-retest reproducibility and hence may serve in some pertinent situations to be an appropriate tool for clinical, basic and applied research.

In **Chapter 7** we described the study protocol of the Dutch school-based program ***'Focus on Strength'*** that aimed to improve body composition of 11–13 year old students, and with that to ultimately improve their quality of life. The development of this intervention was based on the Intervention Mapping (IM) protocol, which starts from a needs assessment, uses theory and empirical research to develop a detailed intervention plan, and anticipates program implementation and evaluation. This novel intervention targeted first year students in preparatory secondary vocational education (11–13 years of age). Teachers were the program implementers. One part of the intervention involves a 30 % increase of strength exercises in the physical education lessons. The other part is based on Motivational Interviewing, promoting autonomous motivation of students to become more physically active outside school. Performance and change objectives are described for both teachers and students. The effectiveness of the intervention was going to be tested in a Randomized Controlled Trial in nine Dutch high schools.

PART IV AN EFFECTIVE PROGRAM? reports on the effect of the ***Focus on Strength*** program on body composition as proxy for health.

In **Chapter 8** we described the study that examined the influence of a combined strength exercise and motivational program –embedded in the school curriculum– on adolescent's body composition and daily physical activity. The program started in March 2015 and ended one year later in March 2016. A total of 695 adolescents (11-15y) from nine Dutch high schools participated in a one year cluster randomized controlled trial. In the intervention schools, physical education (PE) teachers were instructed to spend 15-30 minutes of all PE lessons (2x/week) on strength exercises. Monthly motivational lessons were given to stimulate students being more physically active. The control schools continued their usual curriculum. The primary outcome measure was body composition assessed by the deuterium dilution technique. Daily physical activity measured by accelerometry served as secondary outcome. After 1 year, a 1.6% fat mass difference was found in favor of the intervention group (p=.007). This reflected a 0.9kg difference in fat-free mass (intervention>control;p=.041) and 0.7kg difference in fat mass (intervention<control;p=.054). Daily PA decreased from baseline to posttest in both groups, but less in the intervention group (p=.049). After 1 year, no differences in sedentary behavior, or light physical activity were found between groups. After 1 year, a difference of 0.4% was found for moderate to vigorous physical activities in favor of the intervention group (p=.046). We concluded that the combination of 15-30 minutes of strength exercises per PE lesson and motivational lessons contributes to an improvement in body composition and a lower decrease in physical activity level in 11-15 year olds.

In our last and final part, **PART V NOW WHAT?** the ***Focus on Strength*** idea, program, and outcomes are discussed.

In **Chapter 9** we discussed the outcomes and implications of the research project. In our Theoretical considerations we first focused on the usefulness of Intervention Mapping as the guiding process. Our project moreover illustrates the beneficial effects of real interdisciplinary research as well as the necessity of a socio-ecological, intersectoral approach, involving parents, teachers and school managements. We argue that Self Determination Theory and Social Comparison Theory are not in conflict when adolescents perform in a group setting: positive social experiences of overweight youngsters with resistance exercises may increase their perceptions of competence, their self-worth, and in time, their intrinsic motivation for exercise. We suggested broadening the Theory of Expanded, Extended and Enhanced Opportunities and add Enriched prior to the other three.

In our Methodological considerations we first focused on the dilemma of using golden standard measures versus including a high number of students in a cluster randomized trial. All measurements were chosen based on an estimation of their burden to the participants versus their validity and reliability. We chose deuterium dilution as a reliable method to assess fat mass percentage in normal weight and obese subjects; even while the method is expensive and is seen as a high burden by some of the students. We evaluated and decided to use the back-leg-chest (BLC) dynamometer as an effective, simple and portable way to test total body strength. For physical activity in daily life, the Actigraph GT3X accelerometer was used, however compliance was lower than expected. All available data were included into the analysis using a method that is valid under so-called missingness at random (MAR), however, we were not able to rule out bias arising from missingness not at random (MNAR).

Finally, we discussed future research and implementation of our intervention. We need to know more about the psychological determinants and outcomes of strength exercise behavior. We also suggested giving feedback on body composition instead of weight loss to improve psychological outcomes. The potentially hindering or facilitating role of the parents needs more attention. The basic idea of our approach is simple and easily implementable, but we want to involve physical education teachers and school managers to further improve implementation and to facilitate strength exercises outside the school. We concluded that as long as strength exercises are performed under qualified supervision, they might have positive long-term health benefits.

Samenvatting

In deel I van deze dissertatie **DEEL I DE INTRODUCTIE VAN EEN IDEE** hebben we de gedachte achter het ***Kracht van Kracht*** programma geïntroduceerd: In **Hoofdstuk 1** vanuit een meer biologisch perspectief, in **Hoofdstuk 2** vanuit een meer psychologisch perspectief.

In **Hoofdstuk 1**, het biologische perspectief, hebben we benadrukt hoe belangrijk het is om biologische en psychologische kennis te combineren. Steeds meer jongeren hebben extreem overgewicht (obesitas), en deze jongeren worden steeds vaker te zware volwassenen. Wanneer men kijkt naar lichaamssamenstelling hebben jongeren met overgewicht niet alleen een hogere vetmassa, maar ook meer spiermassa in vergelijking met hun leeftijdsgenootjes met een gezond gewicht. Daarmee zijn jongeren met overgewicht niet alleen sterker, maar ook vaak beter in krachtinspanningen waarbij de focus ligt op absolute kracht. Onder de juiste omstandigheden kunnen jongeren met overgewicht daardoor meer gemotiveerd raken om krachtinspanningen te doen en om zichzelf uiteindelijk een gezonde leefstijl aan te meten. Op dit moment is het zo dat jongeren met overgewicht niet sporten omdat ze minder presteren dan minder zware jongeren. Tegelijkertijd zorgt het niet-sporten er deels voor dat deze jongeren te zwaar zijn. Om deze vicieuze cirkel te doorbreken, suggereren we dat men niet meer moet focussen op gewicht gecorrigeerd voor iemands lengte (Body Mass Index; BMI) om metabole en mentale gezondheid vast te stellen. Verder moet de focus niet meer zijn op het aanpakken van het gewicht van jongeren met overgewicht – wat stigmatiserend kan werken – maar op het verbeteren van lichaamssamenstelling bij *alle* jongeren. Tot slot opperen we om te focussen op gezondheidsgedrag dat jongeren *willen* uitvoeren in plaats van de huidige beweegrichtlijnen. Om de vicieuze cirkel te doorbreken kunnen krachtinspanningen uitkomst bieden.

In **Hoofdstuk 2,** het psychologische perspectief, benadrukken we krachtinspanningen voor jongeren met overgewicht als innovatie op het gebied van fysieke activiteit, waarbij een motivatie-interventie kan helpen om deze jongeren te helpen om te starten met krachtoefeningen. Met het gebruik van psychologische principes en technieken kunnen jongeren bewust gemaakt worden van hun krachten en positieve eigenschappen. Alleen dan kunnen lange termijn gedragsveranderingen worden bewerkstelligd. In vergelijking met jongeren op normaal gewicht, zijn jongeren met overgewicht vaak minder goed in staat om te presteren als het gaat om aerobe inspanningen. Deze negatieve ervaringen kunnen ervoor zorgen dat deze jongeren niet meer geïnteresseerd zijn in sporten, of hun motivatie om te sporten volledig verliezen. Wij suggereerden dat jongeren met overgewicht zullen merken dat ze beter zijn in krachtinspanningen ten opzichte van aerobe inspanningen, dat het voor hen makkelijker is om deze uit te voeren en dat hun prestatie beter kan zijn dan die van hun dunnere leeftijdsgenootjes. Een gevolg hiervan kan zijn dat ze zich meer competent voelen en een verhoogde autonome motivatie krijgen om te sporten. Deze autonome motivatie is nodig om lange termijn gedrag te bewerkstelligen. Krachtinspanningen lijken een goede manier te zijn om jongeren met overgewicht gezonder, sterker, zekerder (en in het algemeen beter) te laten voelen.

Hoewel we overtuigd waren van onze ideeën – krachtinspanningen als interventie – waren nog niet alle assumpties wetenschappelijk getest en waren er nog hiaten in onze kennis. Enkele hiervan zijn beschreven in **DEEL II HET JUISTE SPOOR?**

In **Hoofdstuk 3** hebben we de huidige kennis van de ‘psychologische kracht van krachtinspanningen’ voor mensen met overgewicht en obesitas onderzocht door middel van een systematisch literatuuronderzoek. Relevante literatuur werd geïdentificeerd met behulp van de PubMed en PsycINFO databases. Zeventien studies werden geïncludeerd. Er was bijna geen overlap tussen de psychologische uitkomstmaten. Omdat er bijna geen overlap was tussen de verschillende psychologische uitkomstmaten werden deze geordend in acht grote categorieën. Meta-analytische technieken lieten grote heterogeniteit zien in de effect-sizes. Gecombineerd met het lage aantal effect-size schattingen voor elke uitkomstmaat, was een meta-analyse niet mogelijk. Organisatie van de data liet geen overtuigende effecten van krachttraining zien op psychologische uitkomstmaten. Zwakke effecten werden gevonden op eigen-effectiviteit, zelfvertrouwen, inhibitie en psychologische stoornissen (bijvoorbeeld angst en depressive). Ten opzichte van andere interventies werden vergelijkbare effecten van krachtinspanningen op stemming, uitkomstverwachtingen, kwaliteit van leven en stress gevonden. De belangrijkste conclusie van deze review is dat er -naast de sterke theoretische basis waardoor we positieve effecten van krachtinspanningen op psychologische uitkomstmaten verwachten – op dit gebied een groot gat is in de literatuur. Dit onderzoek kiet geen duidelijk beeld zien: Er zijn mogelijke positieve resultaten, maar er is meer onderzoek nodig om conclusies te kunnen trekken.

In **Hoofdstuk 4**, hebben we een brug geslagen tussen biologische en psychologische inzichten met betrekking tot obesitas. Dit hebben we gedaan door de vermoedelijke fysiologische en psychologische voordelen van krachtinspanningen te meten. In deze cross-sectionele studie was de belangrijkste hypothese dat zwaardere mensen meer plezier hebben in het doen van krachtinspanningen ten opzichte van mensen met een lager gewicht, en dat dit verband wordt gemedieerd door vetvrije massa en spierkracht. Een tweede aanname was dat mensen met overgewicht beter zijn in krachtinspanningen en meer plezier hebben in krachtinspanningen ten opzichte van conditie-inspanningen. Lengte, gewicht, lichaamssamenstelling (dat is vet en vetvrije massa door middel van een onderwaterweging), spierkracht (door middel van maximale krachttesten voor de 'leg press' en 'chest press'), maximaal aeroob vermogen (VO2max; met behulp van een fiets ergometer), en psychologische determinanten (dat zijn: attitudes, intenties en motivaties voor krachtinspanningen en aerobe inspanningen met behulp van vragenlijsten) werden gemeten bij 68 deelnemers (18-30 jaar). Significante correlaties werden gevonden tussen gewicht/BMI en vetvrije massa (index) (r's =.70-.80, p's <.001), vetvrije massa en spierkracht (r's = .35 - .55, p's <.05), en spierkracht en attitudes, intenties en motivaties voor krachtinspanningen (r's = .29- .43, p's <.05). Mediatie-analyses lieten zien dat BMI was gerelateerd aan psychologische determinanten via vetvrije massa en spierkracht. Verder waren deelnemers met een hogere BMI significant beter in krachtinspanningen, meer intrinsiek gemotiveerd, en minder ongemotiveerd om krachtinspanningen te doen in vergelijking met aerobe inspanningen (alle p's <.05). Trends in dezelfde richting warden gevonden voor attitudes en intentie (p's <.1). Met deze studie bevestigen we dat krachtinspanningen mogelijk meer worden gewaardeerd door zwaardere mensen. Hierdoor kunnen krachtinspanningen een belangrijk onderdeel zijn van programma's voor mensen met overgewicht of obesitas.

Tot slot, in **Hoofdstuk 5**, hebben we de attitudes van ouders over sporten in het algemeen, aerobe inspanningen, en krachtinspanningen gemeten. Hoewel krachtinspanningen zowel biologische als psychologische gezondheidseffecten hebben voor mensen van alle leeftijden, wordt nog steeds vaak (foutief) gedacht dat deze negatieve gezondheidseffecten hebben voor jongeren. In totaal hebben 314 ouders deelgenomen aan dit onderzoek door een vragenlijst in te vullen over hun eigen fysieke activiteit en dat van hun kind (12-15 jaar oud). Alle ouders waren deelnemer van een online panel dat representatief is voor de Nederlandse bevolking. In de studie onderzochten we ook redenen voor niet-deelname en attitudes over de eigen fysieke activiteit van de ouders, en dat van hun kinderen. Ouders waren consequent positief over aerobe inspanningen, maar waren minder positief over krachtinspanningen. Ouders gaven vaker aan dat hun kind niet mocht deelnemen aan krachtinspanningen (29.6%) ten opzichte van aerobe inspanningen (4%). De reden hiervoor was voornamelijk dat krachtinspanningen volgens de ouders niet gunstig waren voor de optimale fysieke ontwikkeling van hun kind. In deze studie suggereerden we om interventies te ontwikkelen om het begrip van de ouders over de voordelen en mogelijkheden voor krachtinspanningen te verhogen.

Nadat we erachter waren gekomen dat we op het goede spoor zaten in Deel II, werd het kracht-interventieprogramma ontwikkeld in **DEEL III DE ONTWIKKELING VAN EEN INTERVENTIE.**

In **Hoofdstuk 6** evalueerden we de rug-been-borst dynamometer als een effectieve, simpele en gemakkelijk te vervoeren instrument om totale lichaamssterkte te testen. De meest gebruikte dynamometer is de handknijpkracht dynamometer vanwege de kosteneffectiviteit, het gebruiksgemak en omdat deze gemakkelijk is te vervoeren. Een nadeel van de handknijpkracht dynamometer is dat beweegpatronen tijdens deze meting niet vergelijkbaar zijn met beweegpatronen van grotere spiergroepen, of bewegingen die worden uitgevoerd in het dagelijkse leven of tijdens sportprogramma's. Vanwege deze limitatie hebben we de test-hertest betrouwbaarheid en 'kleinst werkelijke verschil' van de rug-been-borst dynamometer getest bij gezonde volwassenen en jongeren, en hebben we onderzocht of handknijpkracht, kniestrek en knie-buigkracht de rug-been-borst kracht konden voorspellen bij volwassenen. Vijfenveertig volwassenen en 58 jongeren namen deel aan het onderzoek. In een eerste sessie werden rug-been-borst kracht, handknijpkracht, en voor de volwassenen isometrische knie buig- en strek-kracht gemeten. In een tweede sessie, 2 tot 5 dagen later, werd de rug-been-borst kracht opnieuw gemeten voor de test-hertest betrouwbaarheid. De correlaties tussen de twee sessies van de rug-been-borstkracht was hoog (alle r's en ICC's >0.92). Bland-Altman-plots vertoonden hoge overeenkomst. Het kleinst werkelijke verschil (en percentage) waren tussen de 14-26 (19%-26%). Kracht variabelen (handknijp, kniestrek-, en knie-buigkracht) verklaarden 87% van de variantie in rug-been-borst kracht. Een stapsgewijze lineaire regressie liet zien dat dominante kniestrek- en buig-kracht de belangrijkste significante voorspellers waren van de rug-been-borst kracht (r2 = 0.86). Deze studie liet zien dat de rug-been-borst dynamometer redelijke test-hertest betrouwbaarheid had en in sommige situaties een bruikbare methode is om te gebruiken op klinisch en wetenschappelijk gebied.

In **Hoofdstuk 7** hebben we het studieprotocol van het Nederlandse schoolprogramma ***'De Kracht van Kracht'*** beschreven. In dit programma was het belangrijkste doel om lichaamssamenstelling van 11-13 jarige leerlingen te verbeteren en daarmee uiteindelijk ook hun kwaliteit van leven. De ontwikkeling van de interventie was gebaseerd op het *Intervention Mapping* (IM) protocol, welke begint met een probleemanalyse. IM gebruikt theorie en empirisch onderzoek om een gedetailleerd interventie plan te ontwikkelen, en anticipeert op de programma implementatie en evaluatie. Deze nieuwe interventie focust op eerstejaars leerlingen van het VMBO (11-13 jaar oud). Onderwijzers waren de uitvoerders van het programma. Het eerste deel van de interventie hield in dat de gymlessen 30% meer krachtinspanningen moesten bevatten. Het tweede deel was gebaseerd op *Motivational Interviewing,* waarbij autonome motivatie van studenten werd verhoogd om ze zo meer fysiek actief te krijgen buiten schooltijd. De prestatie en veranderdoelen zijn beschreven voor zowel de leerlingen als de docenten. De effectiviteit van de interventie zou worden getest in een gerandomiseerde gecontroleerde trial in negen middelbare scholen.

DEEL IV EEN EFFECTIEF PROGRAMMA? rapporteert de invloed van het ***Kracht van Kracht*** programma op lichaamssamenstelling als benadering van gezondheid.

In **Hoofdstuk 8** beschrijven we de studie die de invloed van het gecombineerde krachtinspanningen en motivatie programma – als onderdeel van het schoolcurriculum – op de lichaamssamenstelling en dagelijkse fysieke activititeit van jongeren. Het programma is gestart in maart 2015, en eindigde een jaar later in maart 2016. In totaal hebben 695 jongeren (11-15 jaar) van negen Nederlandse middelbare scholen deelgenomen aan de één jaar durende cluster gerandomiseerd gecontroleerde trial. Op de interventiescholen waren de gymdocenten geïnstrueerd om op zijn minst 15-30 minuten per gymles (2x/week) te besteden aan krachtinspanningen. Maandelijks werden er motivatielessen gegeven om de studenten te stimuleren om meer fysiek actief te zijn. De controle scholen volgden het gebruikelijke curriculum. De primaire uitkomstmaat was lichaamssamenstelling, gemeten met de deuterium dilutie techniek. Dagelijkse fysieke activiteit was de secundaire uitkomstmaat en werd gemeten met accelerometrie. Na 1 jaar vonden we een verschil van 1,6% in vetmassa in het voordeel van de interventiegroep (p=.007). Dit kwam neer op een verschil van 0.9kg in vetvrije massa (interventiegroep>controlegroep; p=0.041) en een 0.7kg verschil in vetmassa (interventiegroep<controlegroep; p=0.054). Dagelijkse fysieke activiteit verminderde van voor- naar nameting, maar nam minder af in de interventiegroep (p=0.049). Na 1 jaar was er geen verschil tussen de groepen in sedentair gedrag of lichte fysieke activiteit. Na 1 jaar was er een verschil van 0.4% voor matig tot zwaar intensieve fysieke activiteit in het voordeel van de interventiegroep (p=0.046). Hieruit concludeerden we dat de combinatie van 15-30 minuten krachtinspanningen in iedere gymles en motivatielessen een bijdrage leveren aan de verbeteringen in lichaamssamenstelling en een lagere afname in fysieke activiteit voor jongeren van 11-15 jaar.

In het laatste deel, **DEEL V WAT NU?** worden het idee, het programma en de uitkomsten van ***De Kracht van Kracht*** bediscussieerd.

In **Hoofdstuk 9** bediscussiëren we de uitkomsten en implicaties van het onderzoeksproject. In ons stuk ‘theoretische overwegingen’ focussen we eerst op het nut van *Intervention Mapping.* Ons project illustreert zowel de voordelige effecten van daadwerkelijk interdisciplinair onderzoek, maar ook de nood van een sociaalecologische, intersectorale benadering, waarbij ouders, docenten en de schooldirecties worden betrokken. We beargumenteren dat de *Self Determination Theory* en *Sociale Vergelijkingstheorie* niet perse tegenstrijdig zijn wanneer jongeren samen presteren in groepen: voor jongeren met overgewicht verhogen positieve sociale ervaringen op het gebied van krachtinspanningen hun perceptie van bekwaamheid, eigenwaarde, en uiteindelijk hun intrinsieke motivatie om te sporten. Ook suggereren we om de *Theory of Expanded, Extended and Enhanced Opportunitie (*De theorie van expansie, extensie en verbetering te verbreden) door hier *Enrichment (*Verrijking*)* aan toe te voegen.

In het stuk ‘methodologische overwegingen’ focussen we eerst op het dilemma tussen het gebruik van gouden standaard methoden versus het includeren van grote aantallen leerlingen in de cluster gerandomiseerde trial. Alle meetmethoden zijn gekozen op basis van enerzijds de inschatting hoeveel de meting van de deelnemers vraagt en anderzijds de validiteit en betrouwbaarheid van het meetinstrument. We hebben gekozen voor deuterium dilutie als betrouwbare methode om vetmassa percentage te meten, zelfs gezien het een relatief dure methode is en deze methode kan worden gezien als ‘te veel gevraagd’ voor sommige studenten. We hebben de rug-been-borst dynamometer geëvalueerd en besloten om deze te gebruiken als simpel, effectieve en gemakkelijk te vervoeren manier om totale lichaamssterkte te meten. Voor fysieke activiteit in het dagelijkse leven hebben we de Actigraph GT3X accelerometer gebruikt, hoewel de deelname aan deze meting lager was dan verwacht. Alle gemeten waarden werden geïncludeerd in de analyses door middel van een methode die valide is onder zogenoemde ‘missingness at random (MAR). Echter konden we niet uitsluiten dat er eventueel vertekening is opgetreden door ‘missingness not at random’(MNAR).

Tot slot bediscussiëren we toekomstig onderzoek en implementatie van de interventie. We willen meer te weten komen over psychologische determinanten en uitkomsten als gevolg van het doen van krachtinspanningen. We suggereren ook dat het geven van feedback over lichaamssamenstelling in plaats van feedback over het gewicht psychologische uitkomsten positief kunnen beïnvloeden. Ook vereist de mogelijke rol van de negatieve houding van de ouders meer aandacht. Het basisidee van onze benadering is simpel en gemakkelijk te implementeren, maar we willen graag de gymdocenten en schooldirecties betrekken om verdere implementatie te verbeteren en om krachtinspanningen buiten de school te faciliteren. We concluderen dat, zolang krachtinspanningen onder de juiste begeleiding worden uitgevoerd, ze mogelijk positieve gezondheidseffecten kunnen hebben op de lange termijn.

Curriculum Vitae

Gill ten Hoor (4 november 1987, Spijkenisse), from Maastricht University, The Netherlands, has a background in biology (2010: MSc Sports & physical activity interventions) and psychology (2011: MSc Health and social psychology). Both disciplines were combined in his research idea: Focus on Strength; resistance exercise training for overweight and obese children and adolescents. For that idea he received the 2012 Kootstra Talent Fellowship and subsequently four year funding by the Netherlands Organization for Health Research and Development.

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